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PHILCO CORPORATION
Computer Division
3900 Welsh Road
Willow Grove, Pa.
A Subsidiary of the Ford Motor Company

SUBSYSTEM SS1A

Final Engineering Report covering the period
1 July 1960 to 31 December 1962
and
Addendum covering the period
1 January 1963 to 1 May 1963

Contract DA-36-039-SC-85146

Department of the Army File No. 39586-PM-60-91-91 (6441)

Sponsoring Agency:
U. S. Army Electronic Research and Development Laboratories
Fort Monmouth, New Jersey

SUBSYSTEM SS1A
(Automatic Data Processing System
for Field Artillery Applications)

FINAL ENGINEERING REPORT
covering the period 1 July 1960 to 31 December 1962
and ADDENDUM
covering the period 1 January 1963 to 1 May 1963

OBJECT:
To design and build two shelter-enclosed,
BASICPAC automatic data processing sub-
systems for field artillery applications.

Contract DA-36-039-SC-85146


Signal Corps Technical Requirements
SCL-1943A dated 15 November 1958 and Amendment No. 4
dated 20 April 1961, BASICPAC Final Design Plan dated
22 January 1960.

Department of the Army File No. 39586-PM-60-91-91 (6441)

Prepared by:
H. I. Glaser, Project Leader

1 May 1963

Philco Approval


S. M. Berkowitz
Manager, Military Computer
Engineering Department


R. W. Atkinson
Group Supervisor
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PHILCO CORPORATION
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| ADDENDUM TO SS1A FINAL ENGINEERING REPORT | |
| DISTRIBUTION LIST | |

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SECTION 1 PURPOSE

The purpose of the work performed under Contract DA-36-039 SC-85146 is to design and build two (2) sheltered automatic data processing subsystems for field artillery applications. Each of these subsystems consists of a shelter-enclosed, medium-size, stored-program, general purpose digital data processor and computer (BASICPAC) with facilities for automatic high-speed transmission of data inserted by a forward observer and automatic display of fire control information at the gun battery.

SECTION 1

PURPOSE

The purpose of the work performed under Contract DA-36-039 SC-85146 is to design and build two (2) sheltered automatic data processing subsystems for field artillery applications. Each of these subsystems consists of a shelter-enclosed, medium-size, stored-program, general purpose digital data processor and computer (BASICPAC) with facilities for automatic high-speed transmission of data inserted by a forward observer and automatic display of fire control information at the gun battery.

SECTION 2

ABSTRACT

This report deals with the design and fabrication of automatic data processing subsystems (SS1A) for field artillery applications. Each subsystem consists of a modified BASICPAC system together with external facilities for automatic entry, transmission, and display of fire-control information. A detailed list of specific items included in each SS1A is presented in the introduction. Many references for additional information are made throughout the report.

A short history of the SS1A project follows the introduction, briefly outlining all major changes in chronological order. Under the heading of logical design, the five major changes (sign storage change, MAB change, timing counter change, non-FIELDATA equipment change, control separation change) affecting the logical structure of the system are briefly described.

The circuit design section only deals with the "temperature fix change" and the clock pulse shaper change. All BASICPAC logic circuits including modifications are described in the SS1A Operation and Maintenance Manual.

The mechanical design of the BASICPAC S-109 shelter system is considerably improved by ten modifications and/or additions. As a result of vibration tests three more modifications are recommended in the mechanical design section.

The section concerning the paper tape set outlines the improvement made in this equipment. The paper tape reader, designed and fabricated by Kleinschmidt Laboratories, Inc. (KLI), showed definite improvement after many months of difficulties. No major redesign or rework, however, was necessary for the KLI paper tape punch. The typewriter and typewriter control unit are also operating satisfactorily now after removal of all major difficulties.

This report includes three final reports by sub-contractors for the SS1A peripheral equipment. These reports are included as appendices and cover the Message Entry Device, the Digital Data Terminal AN/TYC-1 (XC-3) and the Forward Area Display Unit.

An Addendum to this report was completed and approved in time to be included. The Addendum covers the installation at Fort Huachuca of a second input/output converter for the Serial #7 BASICPAC, and its associated programming.

SECTION 3

PUBLICATIONS, REPORTS, AND CONFERENCES

The following formal transmittals of technical information occurred during the period 1 July 1960 to 31 December 1962 of the SS1A Program.

3.1 PUBLICATIONS: forwarded to USAERDL

Philco Specification 9S-3331 Paper Tape Set (SS1A)
Philco Specification 9S-3332 Message Entry Device (SS1A)
Philco Specification 9S-3333 Forward Area Display Unit (SS1A)
Philco Specification 9S-3351 AN/TYC-1 Transmitter and Receiver Units (SS1A)
BASICPAC Program Library - Books 1 through 13
BASICPAC Fielddata Assembly Program Manual - Revision I
FAP II dated September 1962
SS1A Operation and Maintenance Manuals
Volume I General, Shelter System - Description, Set-Up, and Maintenance - dated February 1962
Volume II Part One, Central Processor - Description, Operation, Theory, and Maintenance - dated March 1962
Volume II Part Two, Central Processor - Action Oriented Equations - dated March 1962
Volume II Part Three, Central Processor - Action Oriented Sub Equations - dated March 1962
Volume III Part One, Expansion Units - Description, Operation, Theory of Operation for: Input-Output Converter, Communications Converter, and Package Tester - dated February 1962
Volume III Part Two, Expansion Units - Action Oriented Equations - dated April 1962
Volume III Part Three, Expansion Units - Action Oriented Sub Equations - dated March 1962
Volume IV Part One, Paper Tape Set - dated January 1962
Volume IV Part Two, Message Entry Device - dated August 1962
Volume IV Part Three, Digital Data Terminal AN/TYC-1 (XC-3) - dated May 1962
Volume IV Part Four, Forward Area Display Unit - dated August 1962
Volume V Part One, Programmers Reference Manual - dated December 1962

| | |
|-------------------------|-------------------------------------|
| BASICPAC No. 6 Log Book | 9 December 1961 to 31 December 1961 |
| BASICPAC No. 6 Log Book | 1 January 1962 to 31 March 1962 |
| BASICPAC No. 7 Log Book | 1 January 1962 to 31 March 1962 |
| BASICPAC No. 6 Log Book | 1 April 1962 to 30 June 1962 |
| BASICPAC No. 7 Log Book | 1 April 1962 to 30 June 1962 |
| BASICPAC No. 6 Log Book | 1 July 1962 to 30 September 1962 |
| BASICPAC No. 7 Log Book | 1 July 1962 to 30 September 1962 |
| BASICPAC No. 6 Log Book | 1 October 1962 to 31 December 1962 |
| BASICPAC No. 7 Log Book | 1 October 1962 to 31 December 1962 |

Changes in Kleinschmidt Paper Tape Sets
Switch Core Replacement Procedure

3.2 LECTURES - None.

3.3 REPORTS

Monthly Performance Summary No. 1; for July 1960
Contract Controls Report; for July 1960
Monthly Performance Summary No. 2; for August 1960
Contract Controls Report; for August 1960
First Quarterly Progress Report; for 1 July 1960 to 30 September 1960
Monthly Performance Summary No. 3; for September 1960
Contract Controls Report; for September 1960
Monthly Performance Summary No. 4; for October 1960
Contract Controls Report; for October 1960
Monthly Performance Summary No. 5; for November 1960
Contract Controls Report; for November 1960
Second Quarterly Progress Report; for 1 October 1960 to 31 December 1960
Contract Controls Report; for December 1960
Monthly Performance Summary No. 7; for January 1961
Contract Controls Report; for January 1961
Monthly Performance Summary No. 8; for February 1961
Contract Controls Report; for February 1961
Third Quarterly Progress Report; for 1 January 1961 to 31 March 1961
Contract Controls Report; for March 1961
Monthly Performance Summary No. 10; for April 1961
Contract Controls Report; for April 1961
Monthly Performance Summary No. 11; for May 1961
Contract Controls Report; for May 1961
Fourth Quarterly Progress Report; for 1 April 1961 to 30 June 1961
Contract Controls Report; for June 1961
Monthly Performance Summary No. 13; for July 1961

Contract Controls Report; for July 1961
Monthly Performance Summary No. 14; for August 1961
Contract Controls Report; for August 1961
Fifth Quarterly Progress Report; for 1 July 1961 to September 1961
Monthly Performance Summary No. 15; for September 1961
Contract Controls Report; for September 1961
Monthly Performance Summary No. 16; for October 1961
Contract Controls Report; for October 1961
Monthly Performance Summary No. 17; for November 1961
Contract Controls Report; for November 1961
Monthly Performance Summary No. 18; for December 1961
Contract Controls Report; for December 1961
Monthly Performance Summary No. 19; for January 1962
Contract Controls Report; for January 1962
Monthly Performance Summary No. 20; for February 1962
Contract Controls Report; for February 1962
Monthly Performance Summary No. 21; for March 1962
Contract Controls Report; for March 1962
Monthly Performance Summary No. 22; for April 1962
Contract Controls Report; for April 1962
Monthly Performance Summary No. 23; for May 1962
Contract Controls Report; for May 1962
Monthly Performance Summary No. 24; for June 1962
Contract Controls Report; for June 1962
Monthly Performance Summary No. 25; for July 1962
Contract Controls Report; for July 1962
Monthly Performance Summary No. 26; for August 1962
Contract Controls Report; for August 1962
Monthly Performance Summary No. 27; for September 1962
Contract Controls Report; for September 1962
Monthly Performance Summary No. 28; for October 1962
Contract Controls Report; for October 1962
Monthly Performance Summary No. 29; for November 1962
Contract Controls Report; for November 1962
Monthly Performance Summary No. 30; for December 1962
Contract Controls Report; for December 1962
Monthly Performance Summary No. 31; for January 1963
Contract Controls Report; for January 1963
Monthly Performance Summary No. 32; for February 1963
Contract Controls Report; for February 1963
Monthly Performance Summary No. 33; for March 1963
Contract Controls Report; for March 1963
Monthly Performance Summary No. 34; for April 1963
Contract Controls Report; for April 1963

3.4 CONFERENCES

1. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 30 June 1960
Subject: First Monthly SS1A Technical Meeting
Participants:

USAERDL

PHILCO

W. Cave
J. Cox
E. Lieblein
G. Sumrall

S. Berkowitz
W. Bradley
A. Carroll
G. Frater
F. LaVerghetta
H. Schwartz
V. Sontag
F. Ungerman

2. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 5 July 1960
Subject: AN/TYC-1 and Message Entry Device (MED)

USAERDL

PHILCO

STELMA, INC.

W. Cave
J. Cox
G. Sumrall
J. Tucker

G. Bekampis
F. LaVerghetta
H. Schwartz

N. Kramer

3. Place: USAERDL, Fort Monmouth, New Jersey
Date: 14 July 1960
Subject: Specs. for MED, FADU, and AN/TYC-1; SS1A

USAERDL

PHILCO

USAEPG

STELMA

G. Sumrall
W. Cave
J. Beattie*
D. Tucker*
R. Mattson*

G. Bekampis
H. Schwartz
F. Ungerman

Lt. J. McDonnel

J. Corless*

* Part Time Attendance

4. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 4 August, 1960
Subject: Second Monthly SSIA Technical Meeting
Participants:

USAERDL

PHILCO

W. Cave
J. Cox
E. Lieblein
G. Sumrall

S. Berkowitz
W. Bradley
A. Carroll
G. Frater

F. LaVerghetta
H. Schwartz
V. Sontag
F. Ungerman

5. Place: USAERDL, Fort Monmouth, New Jersey
Date: 11 August 1960
Subject: Specs. for FADU, MED, and Paper Tape Set
Participants:

USAERDL

PHILCO

J. Beattie
D. Haratz
G. Sumrall

H. Glazer
F. LaVerghetta
H. Schwartz
F. Ungerman

6. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 17 August 1960
Subject: Specifications for Paper Tape Set
Participants:

USAERDL

PHILCO

G. Sumrall
L. Sarlo

H. Glazer
F. LaVerghetta
F. Ungerman

7. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 23 August 1960
Subject: Review Final Specifications for FADU, MED, and Paper Tape Set
Participants:

USAERDL

PHILCO

G. Sumrall
E. Lieblein

S. Berkowitz
G. Frater
F. LaVerghetta
H. Schwartz
F. Ungerman

8. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 1 September 1960
Subject: Third Monthly SS1A Technical Meeting
Participants:

USAERDL

PHILCO

W. Cave
G. Sumrall

S. Berkowitz
W. Bradley
F. LaVerghetta
V. Sontag
F. Ungerman

9. Place: USAERDL, Fort Monmouth, New Jersey
Date: 13 September 1960
Subject: Review Proposals for MED and FADU
Participants:

USAERDL

PHILCO

W. Cave
J. Cox
G. Sumrall
J. Mahr
A. DeRosa
Mr. Dauberschmidt

H. Glazer
F. LaVerghetta
H. Schwartz
J. Standeven

10. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 30 September 1960
Subject: Fourth Monthly SS1A Technical Meeting
Participants:

USAERDL

PHILCO

W. Cave
J. Cox
E. Lieblein
G. Sumrall

W. Bradley
F. LaVerghetta
H. Schwartz
F. Ungerman

11. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 9 November 1960
Subject: Fifth Monthly SSIA Meeting
Participants:

USAERDL

PHILCO

J. Cox
E. Lieblein

W. Bradley
F. LaVerghetta
R. Ferguson

12. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 18 November 1960
Subject: Discussion of SSIA Application Requirements
Participants:

USAERDL

PHILCO

FORT HUACHUCA

J. Cox
E. Lieblein
G. Sumrall

S. Berkowitz
F. LaVerghetta
H. Mellinger
H. Nyser
H. Schwartz
F. Spera

Lt. P. Enslow

13. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 5 December 1960
Subject: Sixth Monthly SSIA Meeting
Participants:

USAERDL

PHILCO

J. Cox
E. Lieblein

S. Berkowitz
F. LaVerghetta
H. Schwartz
V. Sontag

14. Place: USAEPG, Fort Huachuca, Arizona
Date: 8 and 9 December 1960
Subject: SSIA Development and Applications
Participants:

USAEPG

PHILCO

Major G. Black
J. Borrowman
J. Clark
Lt. D. Dimmick
F. Donaldson
Lt. P. Enslow
Lt. J. McDonnell
Lt. S. Pelosi
C. Rowe

F. LaVerghetta
H. Mellinger
H. Schwartz

15. Place: USAERDL, Fort Monmouth, New Jersey
Date: 12 January 1961
Subject: Seventh Monthly SSIA Meeting
Participants:

USAERDL

PHILCO

J. Beattie*
D. Bonda*
J. Cox
E. Lieblein

W. Bradley
F. LaVerghetta
H. Schwartz

16. Place: SERVOMECHANISMS, INC., El Segundo, California
Date: 26 and 27 January 1961
Subject: Forward Area Display Unit Final Design Plan
Participants:

USAERDL

PHILCO

USAEPG

SM/I

J. Cox

H. Glazer

Lt. P. Enslow

B. Hayden
E. Knell
N. Timares

*Part Time Attendance

17. Place: USAERDL, Fort Monmouth, New Jersey
Date: 1 February 1961
Subject: Forward Area Display Unit Final Design Plan
Participants:

USAERDL

PHILCO

J. Cox
E. Lieblein

H. Glazer
H. Schwartz

18. Place: STELMA, Inc., Stamford, Connecticut
Date: 10 February 1961
Subject: Final Design Plans - Message Entry Device and AN/TYC-1 Transmitter and Receiver
Participants:

USAERDL

PHILCO

STELMA

J. Cox
A. DeRosa

H. Glazer
H. Schwartz

A. Brooks
N. Kramer
B. Krauss

19. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 15 February 1961
Subject: Eighth Monthly SSIA Meeting
Participants:

USAERDL

PHILCO

J. Cox
E. Lieblein

S. Berkowitz
H. Glazer
F. LaVerghetta
H. Schwartz

20. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 8 March 1961
Subject: Ninth Monthly SSIA Meeting
Participants:

USAERDL

CONARC

PHILCO

J. Cox
E. Lieblein

Major Munson
Lt. Col. Wojack

S. Berkowitz
A. Carroll
H. Glazer
F. LaVerghetta
H. Schwartz

21. Place: USAERDL, Fort Monmouth, New Jersey
Date: 15 March 1961
Subject: SSIA Training Program
Participants:

USAERDL

PHILCO

USASCS

J. Cox
E. Lieblein

D. Biles
H. Glazer

Mr. Friedman
W. O. Patterson
Mr. Porter

22. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 24 April 1961
Subject: Tenth Monthly SSIA Meeting
Participants:

USAERDL

PHILCO

J. Cox
E. Lieblein

S. Berkowitz
H. Glazer
F. LaVerghetta
H. Mellinger*
V. Sontag*
F. Spera*

23. Place: STELMA, Inc., Stamford, Connecticut
Date: 25 April 1961
Subject: Progress on MED and AN/TYC-1
Participants:

USAERDL

PHILCO

STELMA

J. Cox

H. Glazer
F. Spera

A. Brooks
N. Kramer
B. Krauss
H. Robbins

* Part Time Attendance

24. Place: USAERDL, Fort Monmouth, New Jersey
Date: 8 May 1961
Subject: Revise SS1A Shelter Requirements
Participants:

USAERDL

PHILCO

J. Cox
E. Lieblein

H. Glazer
F. LaVerghetta
H. Schwartz
F. Spera

25. Place: STELMA, Inc., Stamford, Connecticut
Date: 27 June 1961
Subject: Delivery Schedules, MED and AN/TYC-1
Participants:

USAERDL

PHILCO

USAEPG

STELMA

J. Cox
J. Stout

H. Glazer
V. Sontag

Capt. P. Enslow

J. Corliss
Dr. N. Kramer

26. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 28 June 1961
Subject: Eleventh Monthly SS1A Meeting
Participants:

USAERDL

PHILCO

USAEPG

J. Cox
E. Lieblein

S. Berkowitz
H. Glazer
H. Schwartz
V. Sontag
F. Spera

Capt. P. Enslow

27. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 15 August 1961
Subject: Twelfth Monthly SS1A Meeting
Participants:

USAERDL

PHILCO

J. Cox
R. Hansen

R. Atkinson
S. Berkowitz
H. Glazer
H. Mellinger
V. Sontag

28. **Place:** Philco Corporation, Willow Grove, Pennsylvania
Date: 28 and 29 September 1961
Subject: Thirteenth Monthly SSIA Meeting
Participants:

USAERDL

J. Cox
R. Hansen
E. Lieblein

USAEPG

Capt. F. Buckley

PHILCO

R. Atkinson
S. Berkowitz
H. Glazer
H. Mellinger
V. Sontag

29. **Place:** Philco Corporation, Willow Grove, Pennsylvania
Date: 19 and 20 October 1961
Subject: SSIA Programming Meeting
Participants:

USAERDL

D. Clark
R. Hansen
E. Lieblein
G. Sumrall

PHILCO

R. Atkinson
S. Berkowitz
A. Carroll*
I. Johnston*
H. Mellinger *
V. Sontag*
W. Sumerlin*

30. **Place:** Philco Corporation, Willow Grove, Pennsylvania
Date: 21 December 1961
Subject: Fourteenth Monthly SSIA Meeting
Participants:

USAERDL

J. Cox
R. Hansen

PHILCO

R. Atkinson
S. Berkowitz
H. Mellinger
V. Sontag

***Part Time Attendance**

31. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 21 March 1962
Subject: Fifteenth Monthly SS1A Meeting
Participants:

USAERDL

PHILCO

J. Cox
R. Hansen
E. Lieblein

R. Atkinson
S. Berkowitz
H. Glazer
H. Mellinger
H. Nyser*

32. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 14 June 1962
Subject: Sixteenth Monthly SS1A Meeting
Participants:

USAERDL

PHILCO

R. Hansen
S. Homa
E. Lieblein

R. Atkinson*
S. Berkowitz
F. Coyne*
D. Evans*
H. Glazer*
H. Mellinger
H. Nyser*
C. Pafort*
H. Schwartz

33. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 23 July 1962
Subject: Seventeenth Monthly SS1A Meeting
Participants:

USAERDL

PHILCO

S. Homa
E. Lieblein

R. Atkinson
S. Berkowitz
D. Evans*
H. Mellinger

* Part Time Attendance

34. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 13 and 14 September 1962
Subject: Eighteenth Monthly SSIA Meeting
Participants:

USAERDL

USASCS

PHILCO

S. Homa

F. Boynton
Capt. E. Wilder

R. Atkinson
D. Biles
H. Glazer
H. Mellinger

35. Place: Philco Corporation, Willow Grove, Pennsylvania
Date: 15 November 1962
Subject: Nineteenth Monthly SSIA Meeting
Participants:

USAERDL

USASCS

PHILCO

S. Homa
E. Lieblein

F. Boynton
R. Strasser

R. Atkinson
S. Berkowitz
H. Glazer
H. Mellinger

SECTION 4 FACTUAL DATA

4.1 INTRODUCTION

This contract covers the design and fabrication of two automatic data processing sub-systems (SS1A) for field artillery applications. Each sub-system, designated "Computer Set, Digital Data, General Purpose, Model AN/TYK-6(v), " and referred to as Philco BASICPAC's Serial Numbers 6 and 7, consists of: 1) a BASICPAC system similar to the prototype developed by Philco under Contract DA-36-039-SC-78132, modified to include a second 4,096 word memory unit, six additional communications channels and provisions for a second I/O unit; and 2) external facilities for automatic entry, transmission, and display of fire-control information. Each BASICPAC is housed in an S109()/G Shelter.

The shelter layout is illustrated in Figure 1. The location of the units of the computer within the cabinets is illustrated in Figure 2.

The following specific items are included in each SS1A sub-system.

| <u>Quantity</u> | <u>Item</u> | <u>Purpose</u> |
|-----------------|---|--|
| 1 | BASICPAC Central Processor consisting of: one Arithmetic Unit one Program Unit one Control Unit one 4096-word Memory Unit one Power Supply Cabinets one Control Panel Interconnecting Cables | A medium-size, stored-program, general-purpose, digital data processor and computer employing serial-parallel computation and data transfer |
| 1 | Additional BASICPAC 4096-word Memory | Increases the computer core memory to 8192 words |
| 1 | BASICPAC Input/Output Converter. A second Input/Output Converter is provided in Serial #7 only. (Space and cabling are provided for a second Input/Output Converter in Serial #6.) | Provides buffer synchronization for a selected set of input/output devices. Cabling is provided from magnetic tape unit cabinets to the Input/Output Converter. The connector panel includes provisions for connecting the paper tape set to the Input/Output Converter or to the Control Unit as desired. |

| <u>Quantity</u> | <u>Item</u> | <u>Purpose</u> |
|-----------------|--|---|
| 1 | BASICPAC Communications Converter with seven (7) input and seven (7) output channels | Provides digital transmission between the BASICPAC Central Processor and up to seven two-way real-time communications channels. |
| 1 | Package Tester | Provides facilities for static testing of logic circuits on individual chassis cards. (This unit is not a part of the system, but is required for maintenance.) |
| 1 | Paper Tape Set consisting of: one typewriter one tape reader one tape punch one control unit | Augments the facilities of Control Panel or provides Input/Output Converter input/output, as desired. |
| 4 | Magnetic Tape Units | These units serve as data storage and input/output devices. (These GFE units, intended to be part of the system, were not furnished under this contract.) |
| 2 | Digital Data Terminals, each consisting of: one AN/TYC-1 (XC-3) transmitter one AN/TYC-1 (XC-3) receiver Mounting space and cabling are provided for three (3) additional transmitters and three (3) additional receivers (GFE) | Provide facilities for transmitting or receiving digital data on a real-time basis. |
| 1 | Message Entry Device (MED) | Transmits observation data from a forward observer to a central processing unit. |

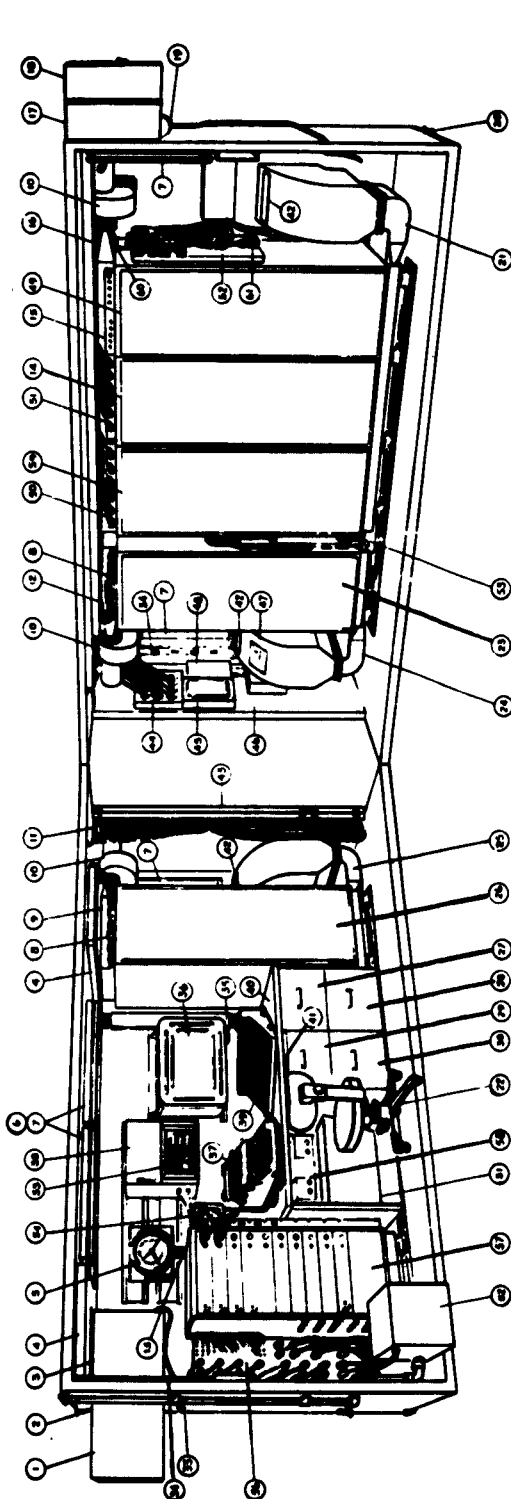
| <u>Quantity</u> | <u>Item</u> | <u>Purpose</u> |
|-----------------|-------------------------------------|--|
| 1 | Forward Area Display Unit (FADU) | Used by field artillery units to provide, at the firing position, visual presentation of fire orders and fire commands transmitted over wire or radio facilities from a digital computer (BASICPAC). |

These items are shown in block diagram form in Figure 3.

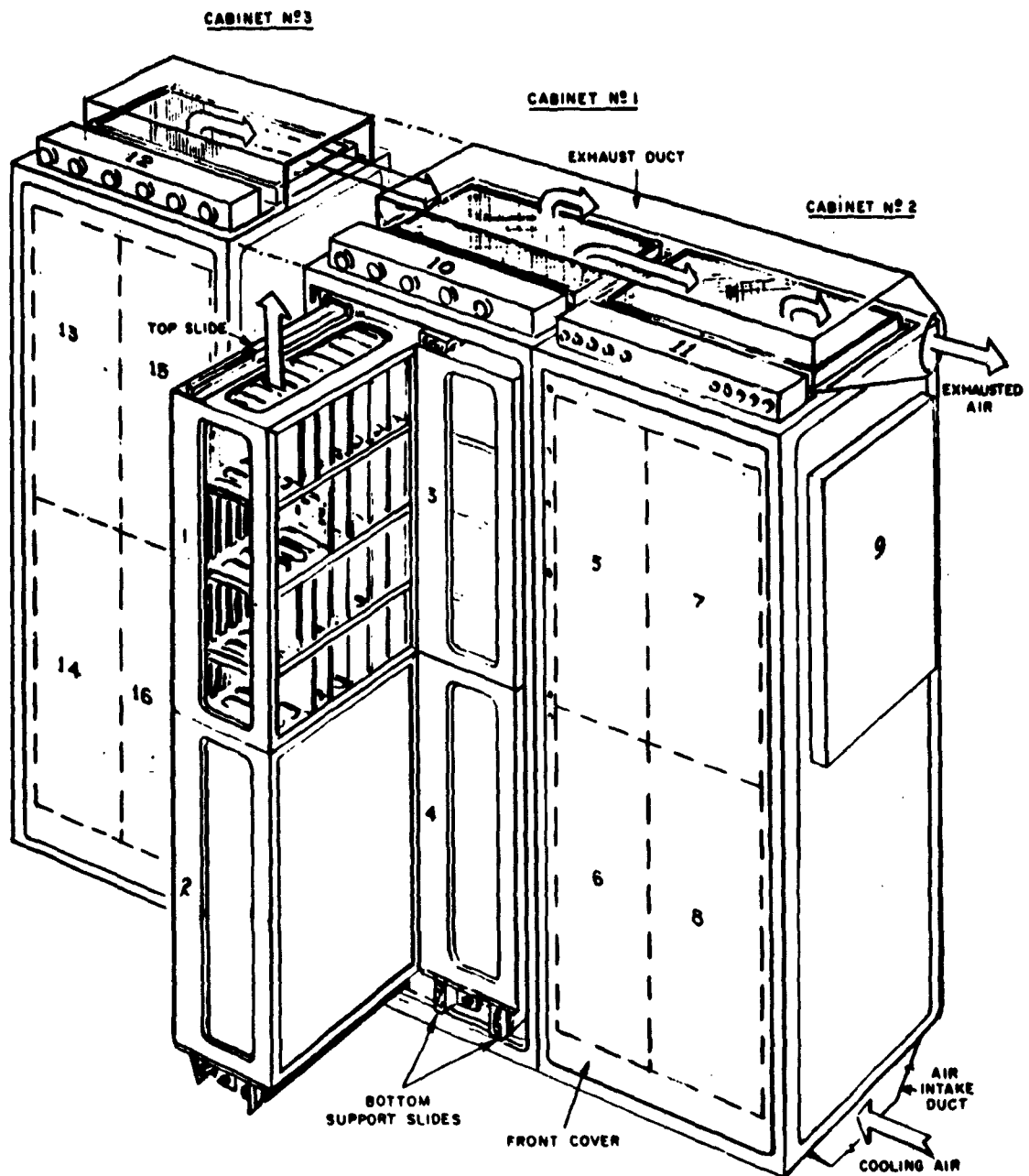
Complete physical description, theory of operation (with logic equations), operating procedures, and maintenance instructions for the entire Shelter System are included in the OPERATION AND MAINTENANCE MANUAL, Volumes I, II, III, IV, and V. This document was delivered to USAERDL as follows:

| <u>Volume No.</u> | <u>Title</u> | <u>Date Delivered</u> |
|-------------------|---|-----------------------|
| I | General, Shelter System | 21 March 1962 |
| II | Part One, Central Processor | 22 May 1962 |
| II | Part Two, Central Processor | 30 March 1962 |
| II | Part Three, Central Processor | 13 April 1962 |
| III | Part One, Expansion Units | 30 March 1962 |
| III | Part Two, Expansion Units | 13 April 1962 |
| III | Part Three, Expansion Units | 13 April 1962 |
| IV | Part One, Paper Tape Set | 27 August 1962 |
| IV | Part Two, Message Entry Device | 6 September 1962 |
| IV | Part Three, Digital Data Terminal AN/TYC-1(XC-3) | 22 May 1962 |
| IV | Forward Area Display Unit | 27 August 1962 |
| V | Programmers Reference Manual | 5 February 1963 |

This final report reviews and summarizes the design and development of the SS1A sheltered BASICPAC System. Logical, mechanical, and circuit design are reviewed briefly in Sections 4.3, 4.4, and 4.5. The major computer design was accomplished under prior Signal Corps Contract DA-36-039 SC-78132 and has been described in detail in Quarterly Reports, Final Design Plan and the Final Report under the aforementioned contract. Contained herein is a description of computer design modification unique to the SS1A BASICPACS (Serial Numbers 6 and 7) and supplemental to information presented in earlier contractual reports delivered under Contract DA-36-039-SC-85146. Also presented are three appendices containing the final reports for the Message Entry Device (Appendix A), the AN/TYC-1(XC-3) Receiver and Transmitter (Appendix B), and the Forward Area Display Unit (Appendix C). These reports, prepared by Philco subcontractors and approved by Philco, constitute a final summary of the design and development of these peripheral equipments to the SS1A System.

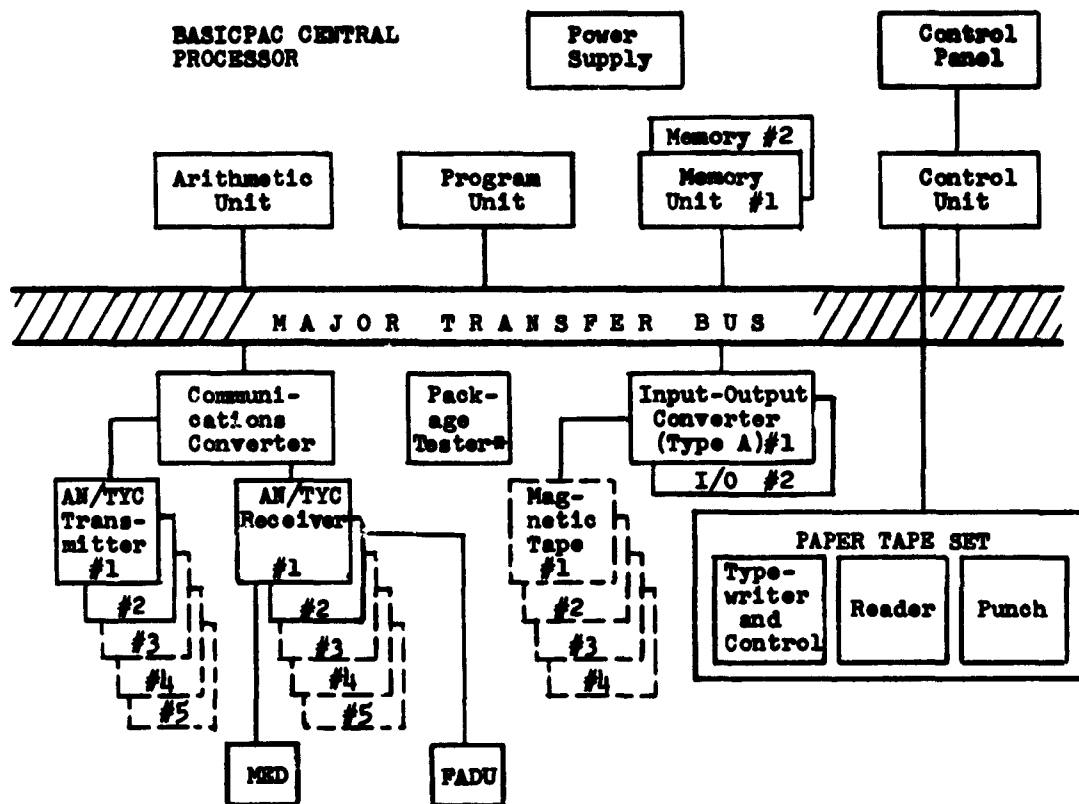


- | | | | |
|------------------------------------|------------------------------------|-------------------------------|---|
| 1. Air Conditioner Condenser Unit | 16. Central Processor Exhaust Duct | 31. Paper Return Receptacle | 46. Power Connector Box |
| 2. Lifting and Tie-Down Ring | 17. Lift Cable Storage | 32. Heater | 47. Turn-On Procedure Instruction Plate |
| 3. Air Conditioner Evaporator Unit | 18. Tie-Down Cable Storage | 33. Air Conditioner Drain | 48. Filter Box |
| 4. Cable Duct | 19. Heater Fuel Tank | 34. Service Outlets | 49. Cabinet Assembly No. 2 |
| 5. Clock | 20. Guide Ring | 35. Package Tester Receptacle | 50. Cabinet No. 3 Connector Panel |
| 6. Luminaire Light | 21. Central Processor Intake Duct | 36. Package Tester | 51. Cabinet No. 1 Connector Panel |
| 7. Fluorescent Light | 22. Chair | 37. Typewriter | 52. Connector Panel |
| 8. MTT Connector Panel Assembly | 23. MTT Cabinet No. 1 | 38. Storage Cabinet | 53. Spare Chair |
| 9. MTT No. 2 Air Exhaust Duct | 24. MTT No. 1 Air Intake Duct | 39. Control Panel | 54. Field Phone |
| 10. Exhaust Blower | 25. MTT No. 2 Air Intake Duct | 40. Console Desk | 55. Intercom |
| 11. Blackout Curtain | 26. MTT Cabinet No. 2 | 41. Pull-Out Wiring Surface | 56. Signal Connector Panel |
| 12. MTT No. 1 Air Exhaust Duct | 27. Paper Tape Punch | 42. Air Intake Filter Cover | 57. TYC Cabinet |
| 13. Thermostat | 28. Typewriter Control | 43. Door | 58. Paper Feed Receptacle |
| 14. Cabinet Assembly No. 1 | 29. Paper Tape Reader | 44. Power Distribution Box | 59. Cabinet Assembly No. 3 |
| 15. Light Box Assembly | 30. Storage Drawer | 45. Circuit Breaker Box | 60. Vane Switch Connector |
| | | | 61. Buzzer |



- | | | |
|----------------------|-----------------------------------|---|
| 1. Arithmetic Unit | 7. Memory Unit No. 2 | 13. Magnetic Tape Storage Unit |
| 2. Program Unit | 8. Input/Output Converter | 14. Magnetic Tape Storage Unit |
| 3. Power Supply | 9. Side Connector Panel | 15. Card Storage Unit |
| 4. Memory Unit No. 1 | 10. Cabinet No. 1 Connector Panel | 16. Space for Second Input/Output Converter (in Serial #7 only) |
| 5. Control Unit | 11. I/O Card and Light Panel | |
| 6. Comm. Converter | 12. Cabinet No. 3 Connector Panel | |

Figure 2. BASICPAC Computer Installation, Front View



* The Package Tester is not a functional part of the system but is required for maintenance.

Note: Cabling is provided from the I/O #1, I/O #2, Communications Converter, AN/TYC Transmitter and AN/TYC Receivers to a connector Panel in the side of the Shelter to facilitate connection of additional devices to these units.

Space and cabling are provided for the units shown in dotted lines, but these units are not supplied.

Figure 3. Computer Set Digital Data General Purpose
AN/TYK-6(v), Block Diagram

4.2 HISTORY OF PROJECT

Contract DA-36-039-SC-85146, dated 17 June 1960, described and specified the design and fabrication of two BASICPAC computers, Serial Nos. 6 and 7, each including a Communications Converter with a full complement of seven input and seven output channels and an Input/Output Converter, Type A. These two computers were to be similar to the Serial No. 1 BASICPAC Computer, developed under Contract DA-36-039-SC-78132, plus a second 4,096 word core Memory. Open bids for the other contractual items included two Universal Control Consoles, four modified (to include 75-bit rate) Digital Data Terminal AN/TYC-1 Transmitters and four Receivers, two Message Entry Devices, and two Forward Area Display Units. The Universal Control Console, however, had a "hold" put on it in the early stages of the contract and was subsequently cancelled by TWX on 31 October 1960. (Documented by Contract Modification No. 4.)

Subcontracts were placed for the other units, as follows:

Stelma, Inc., Stamford, Connecticut, AN/TYC-1 Receiver and Transmitter and Message Entry Device

Servomechanism, Inc., El Segundo, California, Forward Area Display Unit

These subcontractors prepared final reports on their respective units which are submitted as appendices to this final report.

Prior to the production cycle on the two BASICPACS, a system study was made to confirm the capability of the BASICPAC Power Supply to handle the additional currents required for the second memory unit and to determine the optimum routing paths for the Major Transfer Bus (MTB) and Memory Selection Bus (MSB).

A number of logical changes were made, as found necessary by the addition of the second memory and six communications converter channels. These changes generally take the form of address modifications and selection. Changes were made in cards in the Memory Unit, the Communications Converter, Input/Output Converter and the Program Unit.

In addition, cabling changes were made in two general categories; 1) the transfer of non-permanent termination blocks to new locations, and 2) the addition of cabling to connect the second Memory and Communications Converter channels.

In the latter part of April 1961, it was agreed to incorporate the BASICPAC Computers into S-109 shelters, provide an additional cabinet for each machine, and make provision for a second Input/Output Converter for Serial Number 7. The additional tasks are fully described in Contract Modification Number 3, dated 30 October 1961. This modification initiated a re-examination of system timing including MTB path delays and clock and timing delays. As a result of this investigation a change (the MAB change described in the Logic Design section) was incorporated into Serial Numbers 6 and 7; prior to delivery of #7 and later retrofitted in #6 after delivery to Fort Huachuca.

Delivery of both sheltered systems was made to USAERDL, Fort Monmouth, New Jersey, with subsequent delivery to Fort Huachuca, Arizona. Serial #6 was delivered to Fort Monmouth on November 20 1961 and Serial #7 on January 23 1962.

At the time of the MAB change in Serial #6 in May, 1962, a modification to memory current sources, described in circuits section 4.4, was installed in serial #6 memory. Following a period of debugging, after the cable change, the current source cards were further modified in the latter part of September 1962, to correct the temperature problem. During this period, serial #7 was being used successfully by Army and Ramo-Wooldridge personnel with only a minimum of routine maintenance required.

In the first half of October 1962, Timing Procedure debugging, shaper circuit modification and memory tests were performed. Several intermittent problems were found and cleared.

Starting October 22 1962, at Fort Huachuca, serial #6 was subjected to an elevated temperature of 115°F, to evaluate machine performance and isolate memory problems. During these tests, the remaining intermittent problems associated with the memories were resolved and corrected. BRAT and FARM diagnostic routines operated satisfactorily at high, low and nominal marginal check voltages.

From November 6 through December 31 both serial #6 and #7 were available for Army programming and training. During this period an improper cable connection with other equipment caused some damage to the serial #6 communications converter. With the exception of this problem, machine operation was successful with a minimum of other than routine maintenance required.

The second Input/Output Converter unit for serial #7 was assembled, tested and debugged in part, in conjunction with serial #3 system. This unit will be delivered to Fort Huachuca for installation in early January 1963. Final tie-in to the system and debugging, including operation with and final debugging of PACO and SICON diagnostic programs, will be carried out in early 1963 and documented in an addendum to this report.

4.3 LOGICAL DESIGN

The basic logical design is documented in the SS1A Operation and Maintenance Manual, Volume II, Section 4, under Theory of Operation. This includes the word format, order codes, instruction-oriented equations and complete description of all Central Processor Units and functions, including operational controls and indicators. This report reviews briefly the major changes that have evolved during the fabrication of the SS1A Computers.

The "temperature fix", incorporated into the No. 1 BASICPAC in April and May of 1961, was added to Serial Nos. 6 and 7. Also a series of logic changes were made to the system timing to produce special timing pulses which transfer data from the CIS and KIW registers to the MTB earlier with respect to the TF timing.

Some changes were made in the SS1A BASICPACS' logical design during the fabrication and testing of the two systems. These changes increased overall reliability and interface tolerances, and also enabled BASICPAC to accommodate input/output and real-time devices not adhering exactly to FIELDATA specifications. Only one change affects program operation, namely, the control separation change. This change increases the flexibility of the communications converter. The changes and units affected are briefly described below.

Sign Storage Change (Communications Converter)

A modification was made in the error procedure used by an input channel because the indication was ambiguous. In the interpret sign mode, the sign of the stored word or portion of a word indicates the sign received by the input channel. In the non-interpret sign mode, it indicates, in some cases, a character parity error in one of the characters received. An ambiguity existed in the special case where a control character was received immediately following a data character in the sign position. The logic was modified so that the indication, in this case, referred only to parity error, the sign being accessible by means of a sense instruction.

MAB Change (System)

The increased size of the two SS1A systems (over BASICPAC Serial No. 1 and the attendant increased length of the MTB (especially in Serial No. 7, with provision for I/O Unit No. 2), caused several switching spikes in cases where memory control passed from a unit at one end of the MTB to a unit at the other end. In practically all cases no failure was encountered; however, since trouble could arise under extreme temperature conditions, the MAB change was

implemented. This two-fold change created another six-bit bus (MAB) so that "dead" time is allowed on either MTB or MAB while memory control is switched from one unit to another. This prevented inter-unit spikes and also changed gating within some units to control turn-on and turn-off of signals gated to the MTB or the MAB by means of clock adjustment. After these changes, no failure could be made to occur after the system was adjusted and tested over a wide range of operating conditions. The increased tolerance also permits further expansion of the system.

Timing Counter Change (Control Unit)

Since the implementation of the temperature fix, it was found that a large noise pulse, although insufficient to change the state of a given flipflop, could be transferred through the flipflop to its output. This output noise pulse, if widened by certain logic chains, could set a second flipflop. However, if both flipflops are clocked, the noise pulse causes no problems.

The eight-bit unclocked ring Control Unit timing counter had a tendency to drop characters to or from I/O devices because of the spurious noise pulses mentioned above, or by intolerance to out-of-spec pulse widths. The 8-bit counter was replaced by a clocked 3-bit Grey code counter, which increased its tolerance to noise, and removed "forbidden" states. A hardware saving was also effected by this change. Systems with this change implemented have shown excellent reliability in operation with existing paper tape equipment.

Non-FIELDATA Equipment Change (Communications Converter)

The BASICPAC Communications Converter was designed to operate with FIELDATA-interfaces, real-time input-output devices. However, many real-time devices, particularly the AN/TYC Receiver, cannot communicate with the ready-strobe system. To permit reliable communications, the communications converter was changed so that an input channel is set to a preset phase on every channel initiation.

Control Separation Change (Communications Converter)

Various uses for the Communications Converter have required more than the number of channels available in this unit. However, several devices can be multiplexed on a single converter input channel since the maximum operating character rate of each input channel is several orders of magnitude higher than that of most real-time equipment. Therefore, a change was made to facilitate the programming necessary to sort and assemble the information from the various devices, and to make operation with a single device per channel more flexible.

A Communications Converter input channel, before the change, operated as follows:

1. The channel is initiated (set) by program.
2. Characters are received and stored by the channel unit:
 - a. the number of data characters specified by mode and channel type are received and stored, or
 - b. a control character is received and stored
3. Then:
 - a. termination of operation indications are stored,
 - b. interrupt is requested, and
 - c. the channel is returned to the idle state, until 1) above occurs.

After the change, if a control character is received (2a above), the channel is not returned to an idle state, but remains in a "hung-up" state until the program decides what course of action to take. The program may decide to:

1. Start over "from the top" (i. e. start assembling a new data word).
2. Terminate input.
3. Finish the incomplete data word.

Before the change, only remarks 1) and 2) above were possible.

Two other changes were made in communications converter operation. The KAFQ change enables the communications converter to operate reliably with incoming strobe pulses of marginal duration (1 μ s or less). The KAP indication change enables the program to determine the source of an input parity error more easily. Before the change, the following occurred on an input parity error:

1. KAE was set, possibly at the same time as it is being sensed and reset by program, possibly masking the error indication, without being sensed.

2. When the channel interrupted, a minus sign was stored with the interrupt control word, whenever the parity error was associated with the character, word, or set of words causing the interrupt.
3. On a limited interrupt channel, in non-interpret sign mode, a minus sign was stored with the word containing the off ending character, if data.
4. If the input error occurred on a control character, a minus sign was stored with that character.

The following now occurs on an input parity error:

1. KAE is set when the program is "locked out" so that it cannot be sensed and reset at the same time.
2. The interrupt control word is stored in loc. 00004 with a minus sign only when the parity error occurs on a data character received on that channel, since the last time the channel was in a fully reset state (i.e., since the channel was sensed and reset, or initiated a data interrupt request).
3. Same as 3. before
4. The parity error indication on a control character is stored only with that control character.

The change thus: a) makes the KAE flipflop more usable and b) completes the separation of data and control character inputs in regard to error indications

The central processor was modified to fully multiplex control unit input/output operations with converter operations. Before the SGA/CVB change, the control unit paper tape set was considered to be a minimal system only, not to be used simultaneously with converter operations. However, its use as a monitor of real time and buffered input/output strongly indicated the need for multiplexing. The SGA/CVB change accomplishes the multiplexing, guards against possible overriding of input/output converter orders and allows programs to address non-existent memory locations (for operands in Arithmetic and logical instructions, not transfer or sense orders) without causing a computer halt.

Two minor changes were made in the input/output converters to improve clock tolerance. The first allows more time for the parity network to form the parity bit for output characters. The latter change reduces the decode for

sensitive control characters (EOB, EOF, SOB, STOP) from 8 to 7 bits, ignoring the parity bit, although a parity error on these characters is still detected and indicated. This permits a more fail-safe operation, since these characters generally cause stopping, rather than continuation of operation.

Miscellaneous

Other minor logic changes were made, mainly with updating and completing documentation.

4.4 CIRCUIT DESIGN

The circuit design for the BASICPAC computer is based upon the concepts which were previously established in the development of the MOBIDIC computer system. In the process of reviewing and analyzing these design criteria for use in BASICPAC, a series of modifications, improvements, and changes were implemented. These circuits and their modifications have been used entirely in BASICPAC Serial Nos. 6 and 7. The BASICPAC logic circuits are described in the SS1A Operation and Maintenance Manual, Volume II, Section IV.

The SS1A Computers, Serial Nos. 6 and 7, have two significant changes that were first made on the No. 1 BASICPAC. These are the "Temperature Fix change" and the clock pulse shaper change. These modifications, found necessary during the system debugging of the No. 1 BASICPAC, were known early enough to be incorporated into the SS1A computers in the initial stages of their fabrication.

These changes are described below.

The "temperature change" was necessary because the 150-nanosecond pulses could not be reliably propagated through some logic chains. Increasing the clock pulse width and the corresponding minimum flipflop delay corrected this condition. A low temperature sensitive noise problem was corrected by changing a capacitance value.

Modifications were made in the flipflop circuitry to operate with wider input pulses. A new delay element configuration for both inputs was mounted on one sub-module and input speed-up capacitor values were increased to 390 picofarads for delay line termination.

Spurious pulses were generated at the inputs to top transistors in parallel high gate matrices by collector-base coupling.

When the top collector in a high gate was brought to ground by the parallel gate, the charge moved from collector to base in the top transistor and produced a voltage transient at the base which was similar in magnitude to the input voltage. This transient was coupled back to the input via the speed-up capacitor.

When the top transistor was driven by a flip-flop, this positive-going transient reset the flip-flops.

By decreasing the speed-up capacitance, which drove the top flip-flop transistors, the feed-back impedance to a spurious pulse was increased; therefore, the current from the base required to charge this capacitor was reduced.

Tests were conducted which show that by changing the 68 picofarad capacitors which drive top transistors in flip-flops to 33 picofarads, flip-flops were adequately desensitized to spurious pulses at the output.

This configuration is insensitive to temperature and input pulse rise-time and has wide tolerances on input pulse amplitude and width.

The initial clock pulse shaper was similar to that used in MOBIDIC. However, to optimize timing it was decided to use a shaper whose phase and pulse width could be adjusted. Cable delay was minimized by introducing a variable delay at the input to each shaper. The input to the shaper at the source was delayed to correspond with the input to the shaper located in the unit as the cable sink. The delay network was part of the clock pulse shaper.

The clock pulse shaper (figure 4) is a pair of cascaded capacitance-coupled grounded-emitter circuits which are driven by an RC-coupled inverter buffer. The capacitance-coupled stages are biased "on" to produce negative active outputs. The duration of output activity is determined by coupling capacitance and the biasing resistance. The first capacitance-coupled stage determines a delay from the input and the second determines clock pulse width. Variable resistors are used in the bias network for adjustment of these parameters.

A clock pulse amplifier network was designed to decrease the number of logic levels in clock pulse chains. The amplifier is driven directly from the shaper.

The clock pulse amplifier output circuits (figure 5) are emitter-followers. A diode from base to emitter was added to the standard emitter-follower configuration because the signals are narrow and their width is critical. It provides a lower impedance discharge path than that through the emitter resistor to ground. Damping resistors, in series with the output, reduce ringing at the load. One emitter-follower is driven directly by a buffer inverter. Its output also drives an inverter which drives the other emitter-follower, giving a complemented output.

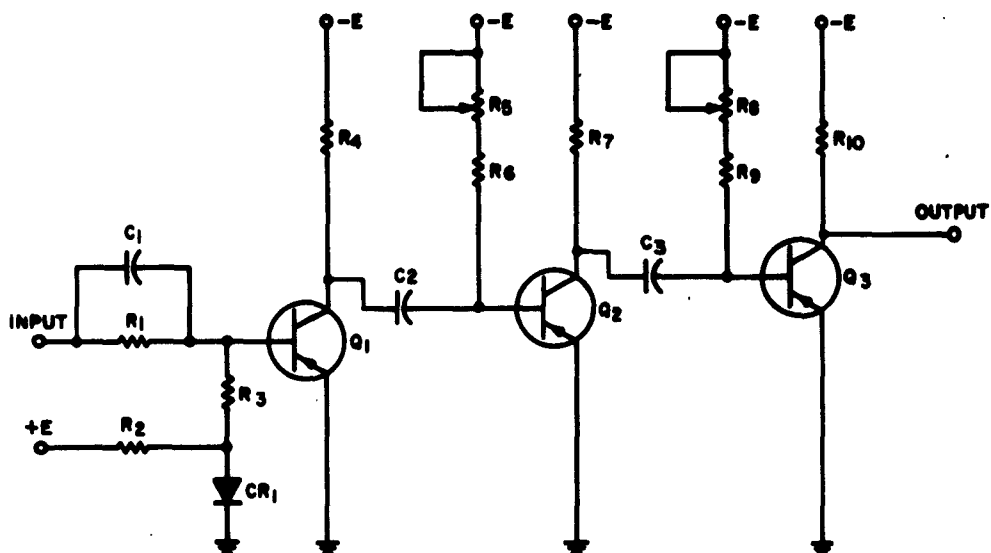


Figure 4. Clock Pulse Shaper

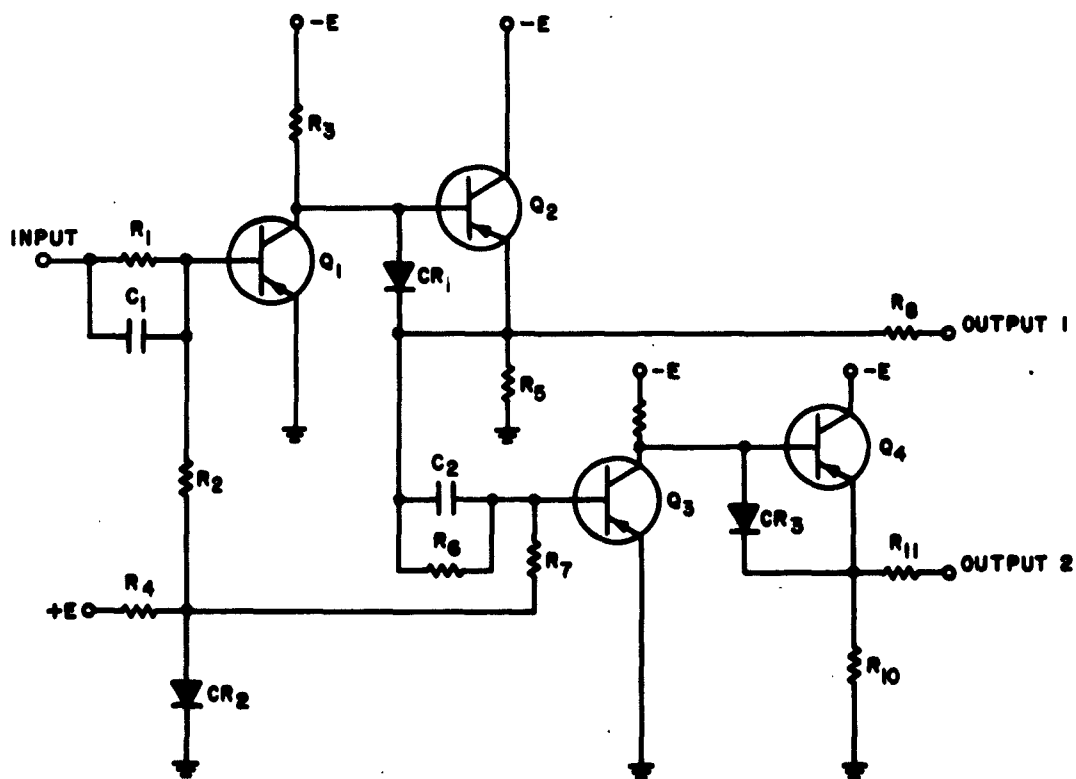


Figure 5. Clock Pulse Amplifier

During the acceptance test of BASICPAC Serial #1 at USAERDL Fort Monmouth, New Jersey, it was found that some difficulties were experienced with tracking of current source with temperature at both temperature extremes. The memory could be made to operate at extreme temperatures when current sources were manually adjusted to proper values.

Investigation of this problem revealed that gain of the first stages of the current sources was not constant with temperature. A circuit modification was made which reduced gain variation to less than 6 percent over the entire range of temperature. This change was incorporated into serial #6 memories at the time of the cable modification in May.

The modification consisted of replacing the second stage transistor with a higher gain unit and the replacement of a resistor with stabistor type diodes to compensate for transistor parameter changes with temperature. These changes are indicated in Figure 6.

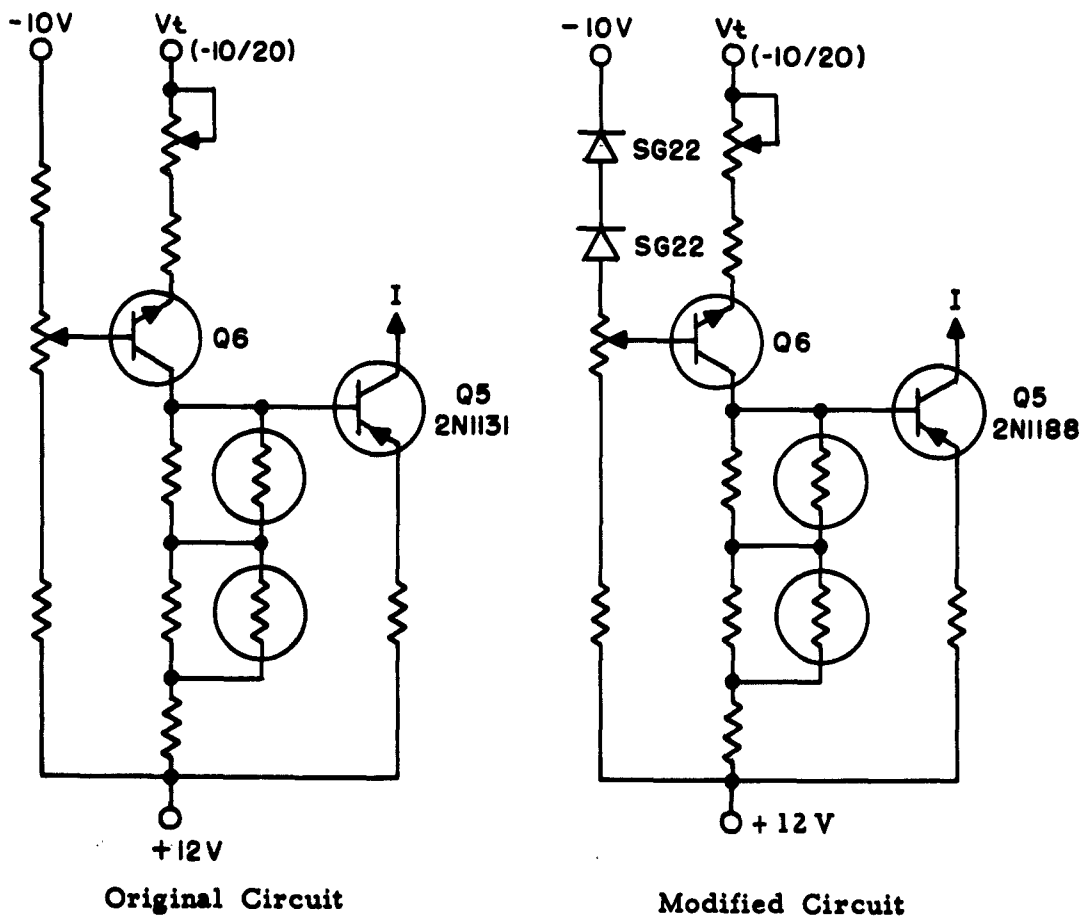


Figure 6. Current Source Modification Number 1

To further improve memory operation, a change in a resistor value in the current source cards, B185 and B186, was incorporated on October 1 to permit adjustment of current sources to the original current levels and slopes specified in the BASICPAC Memory Final Design. This change is shown in Figure 7.

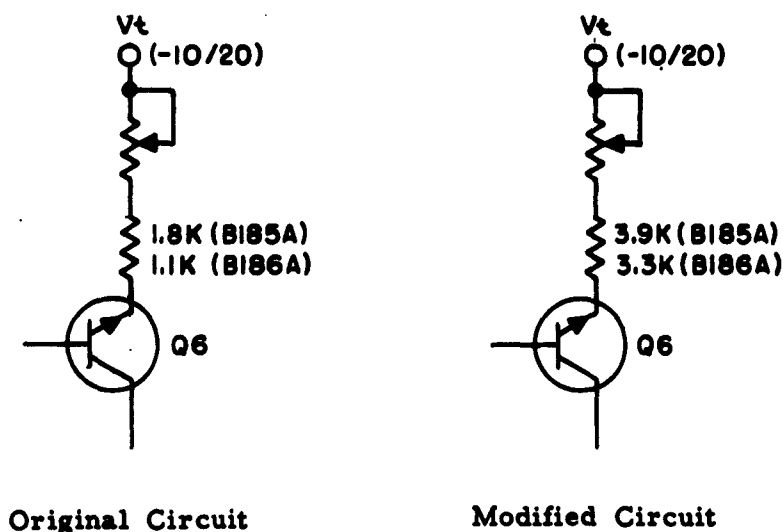


Figure 7. Current Source Modification Number 2

The circuit operation remains as described in Operation and Maintenance Manual Volume II Part 1. Adjustment procedures for the current sources also remain as described in the above referenced document, with the exception that the values to be obtained in adjustment are changed. Optimum values for best memory operation have not been finalized at this writing. Final values will be issued in the form of an erratum at an early date.

4.5 MECHANICAL DESIGN

The final engineering report submitted on Contract No. DA-36-039 SC-78132 contains information which is applicable to both the Serial 6 and Serial 7 systems. Only modifications or additions to the Serial No. 1 shelter system are reviewed in this section.

The Serial 6 and Serial 7 systems are identical except for various additional expansibility features which were provided in Serial 7. The significant changes, as compared to the #1 BASICPAC S-109 shelter system, are briefly described below. A detailed description may be found in the SS1A Operation and Maintenance Manual, Volume I.

1. A third cabinet was added, which is bolted to the left side of cabinet No. 1, and is mounted on structural members common to all 3 cabinets.
 - a. In Serial 6, the 3rd cabinet contains 2 sliding drawers for magnetic tape storage and 2 dummy frames for spare card storage.
 - b. In Serial 7, the 3rd cabinet contains two modified frames for magnetic tape storage, a dummy frame for card storage and a dummy frame for a second I/O Unit containing Burndy cable connectors.
2. A TYC cabinet was installed which contains two (2) sets of AN/TYC-1 (XC-3) Transmitters and Receivers. Provisions are also made for three (3) additional sets of AN/TYC-1 (XC-3) Transmitters and Receivers. This cabinet also includes a patch panel for field wire circuits and a connector panel for computer connections.
3. A signal connector panel was installed in the forward shelter wall (curbside) which provides connections for seven (7) communications converter channels.
 - a. In Serial 6, connections are provided for a 2nd Paper Tape Set on this panel.
 - b. In Serial 7, connections are provided for a 2nd and a 3rd Paper Tape Set, and also 4 additional Magnetic Tape Transports.
4. Mounting brackets are provided on the side of the AN/TYC-1 (XC-3) cabinet for the installation of a GFE field telephone.
5. An intercom for inter-shelter communication is mounted on the curbside wall above the console.

6. The Package Tester was relocated as a result of the above changes.
7. The fire extinguisher was relocated to the shelter door from the roadside rear floor.
8. A fire axe was installed in the shelter.
9. The drawers in the console were modified to accept new lock and latch assemblies.
10. The "MTB" and "MSB" cable groups were rerouted to optimize the electrical characteristics of the computer system.

As a result of recent vibration tests conducted on the No. 1 BASICPAC System, the following minor modifications are recommended for incorporation into Systems No. 6 and No. 7.

1. Reinforcement of the Power Supply transformer tray retaining brackets by the addition of horizontal gussets.
2. Revision of the Package Tester by the addition of an angular frame around the resistor mounting board, and the addition of three (3) fasteners at the top and two (2) fasteners at the bottom of the carrying case for mounting the front panel.
3. Placement of a cable clamp around the TB-1 and TB-2 cable fastened to the bottom plate of the Control Panel Assembly. Addition of safety wires to the hold-down clamps.

4.6 PROGRAMMING

4.6.1 Introduction

On 20 October 1961 a meeting convened at Philco for the purpose of coordinating SS1A programming tasks to ensure conformance with the requirements of U. S. Army Signal Corps and this Contract DA-36-039-SC 85146. The following specific items were established to meet the contractual commitments:

1. Design of COOP and BOAR acceptance tests for BASICPAC Serial Numbers 6 and 7, and provision of paper tapes.
2. Revision of the memory diagnostics, PRAM and WORM, to accommodate testing of a two-memory system.
3. Revision of the Input/Output Converter diagnostic, PACO, to accommodate testing of a two Input/Output Converter system.
4. Preparation of a diagnostic program, SICON, for the testing of two Input/Output converters operating simultaneously.
5. Preparation of diagnostic programs for the testing of the MED, FADU and AN/TYC-1 equipments.
6. Re-design of FAP II for capability of handling subject programs designed for two-memory, two Input/Output Converter systems.
7. Preparation of assembly language listings for Items 2 through 6.
8. Provision of documentation which is sufficient to understand the design and operation of the above items.
9. Revision of the BASICPAC Programming Manual provided under Contract DA-36-039-SC-78132 to update same, and to include changes peculiar to programming the SS1A BASICPAC configuration.

4.6.2 Development Philosophy

The primary goal of the SS1A programming effort was to provide comprehensive diagnostics for use on the expanded BASICPAC Systems, Serial Numbers 6 and 7. Since the "Minimal Programming Aids" supplied under prior U.S. Army Signal Corps Contract No. DA-36-039-SC-78132 were designed to permit extension for use on expanded systems, the basic programs of this

library were selected to form the foundation of the SS1A diagnostic library. These programs were expanded and/or revised to meet the requirements of BASICPAC Serial Numbers 6 and 7 by a team comprising both experienced design engineering and programming personnel.

4.6.3 Project Scope and Status

1. Design of COOP and BOAR acceptance tests for BASICPAC Serial Numbers 6 and 7 and provision of tapes

COOP (The Continuous Operations Test) is a rigorous and all-inclusive equipment test constructed from the diagnostic and mathematical routines from the original BASICPAC library. Control of processing is provided by a COOP executive routine and a computational program which initiates extensive self-checking calculations. BOAR (The BASICPAC Operational and Arithmetic Routine) is based on the BASICPAC General Test plus a set of double precision service routines. COOP and BOAR are provided for customer acceptance testing: COOP is designed for use during the rigorous and formal acceptance test procedures, and BOAR for daily examination of machine status.

Since both programs were used extensively and successfully on the BASICPAC Number 1 system, effort on this task was limited to the addition of the programming required for diagnosis of second memory functioning and seven-channel, limited-interrupt Communications Converter operations.

Coding and debugging of the program revisions were completed in November, 1961 and preparation of triplicate sets of COOP and BOAR tapes commenced immediately thereafter. Final testing of these tapes was performed on the BASICPAC Number 6 system, and 2 sets of tapes were delivered with each BASICPAC. Both COOP and BOAR programs were utilized during acceptance testing of BASICPAC Number 7 at Fort Monmouth, New Jersey during April 1962.

2. Revision of the memory diagnostics, PRAM and WORM, now combined in FARM, to accommodate testing of a two-memory system

During specification of the revised PRAM (Pseudo Random Memory Test) and WORM (Worst Pattern Memory Test) programs, engineering personnel requested that consideration be given to combining the presently existing memory diagnostics into a single program. Programming personnel examined the feasibility of this approach and determined that no additional effort would be required to implement the combined diagnostic. Accordingly, a preliminary specification of FARM (Fixed and Random Memory Test), designed for the testing of a two-memory system and comprising all the previous memory diagnostic functions, was prepared. USAERDL personnel approved the new specification and detailed flow charting and coding commenced in March 1962.

Book 4 (Revision 1) of the BASICPAC Program Library containing program description, operating instructions, flow charts and program listings for FARM was completed and delivered in October 1962. Final program tapes for FARM will be completed and shipped in January 1963.

3. Revision of the Input/Output Converter diagnostic, PACO, to accommodate testing of a two Input/Output Converter system.

PACO (Paper Tape Test - Input/Output Converter) is designed to test both the operation of an Input/Output Converter and the mechanical and electrical functioning of the Kleinschmidt Typewriter, Paper Tape Punch, and Paper Tape Reader. The original program on the development #1 BasicPac was designed to operate, as specified by the FIELDATA Equipment Intercommunication Characteristics - "Green Book", with a Typewriter connected through Input/Output Converter Number 1. FIELDATA Intercommunication Characteristic, "Orange Book", was specified for the typewriters provided with BASICPAC Serial Numbers 6 and 7. Therefore, considerable program revision was required to provide adequate testing of the modified Typewriters. During investigations of this revision, it became apparent that the functions previously performed by TYPO could be incorporated into PACO without additional effort. With the approval of USAERDL, this further modification was then included in the PACO specifications.

Since continual improvements and associated modifications were made to the Kleinschmidt equipment, a detailed review of PACO testing procedures was undertaken before finalizing the revised PACO specifications. Analysis of actual equipment performance, combined with mechanical and electrical equipment changes, necessitated several basic revisions to the original PACO diagnostic methods. The resulting PACO specification was submitted to USAERDL, with approval received in January 1962.

Flow charting, coding, program description and operating instructions for PACO have been completed. Assembly, debugging and final documentation will commence when #7 BASICPAC system is available with two Input/Output Converters; estimated by March 1963. The work done to complete PACO will be included in the addendum to this report.

4. Preparation of a diagnostic program, SICON, for the testing of two Input/Output Converters simultaneously

SICON (Simultaneous Converter Operations Test) is designed to examine the multiplexing functions performed during simultaneous operation of two Input/Output Converters. Final flow charting, coding, program description, and operating instructions for SICON were completed in April 1962; assembly, debugging and final documentation will commence in March 1963 when #7 BASICPAC system becomes available with two Input/Output Converters. The addendum to this report will include the work done to complete SICON.

5. Preparation of diagnostic programs for the testing of the MED, FADU, and AN/TYC-1 equipments

Two programs have been specified for the diagnosis of these equipments. ANTC (AN/TYC-1 Transmitter and Receiver Test) examines the operation of the AN/TYC-1 units. PEAT (Peripheral Equipment Acceptance Test) tests the functioning of the Message Entry Device and/or the Forward Area Display Unit.

Book 12 of the BASICPAC Program Library containing program descriptions, operating instructions, flow charts, and program listings of PEAT and ANTC was completed and delivered in October, 1962. Final program tapes for the two diagnostics will be completed and delivered in January, 1963.

6. Re-design of FAP II for capability of handling subject programs designed for two-Memory, two Input-Output Converter systems

Re-design of FAP II commenced in October 1961. All necessary additions were specified for utilization of FAP II on the expanded BASICPAC system. Major program revisions were necessitated by the provision of "Orange Book" Typewriters on BASICPAC Serial Numbers 6 and 7, the original FAP II having been designed to produce program listings on the "Green Book" Typewriter.

Coding of the re-designed FAP II has been completed. Final documentation and assembly listing are in progress as of this writing. Delivery of the program document and program tapes are scheduled during March, 1963. The BASICPAC FIELDATA Assembly Program Manual (FAP II) was completed and delivered in September, 1962.

7. Preparation of assembly listings for Items 2 through 6

All coding was prepared in assembly language. Delivered programs (FARM, PEAT, ANTC) and those scheduled for future delivery (PACO, SICON, and FAP II) have been or will be documented with assembly language listings according to the schedules indicated in Items 2 to 6 above.

8. Provision of documentation which is sufficient to understand the design and operation of the above items

Documentation of all items has proceeded concurrently with program specification and preparation. See Items 2 to 6 above for final documentation scheduling.

9. Revision of BASICPAC Programming Manual provided under Contract DA-36-039-SC-78132 to include changes peculiar to programming the SS1A BASICPAC configuration

The BASICPAC Programmer's Reference Manual will be completed and delivered in February, 1963. The manual is organized in a manner suitable for reference usage, and emphasis is placed on the techniques of Input/Output Converter programming for the SS1A systems.

4.7 PAPER TAPE SET

4.7.1 General

The BASICPAC Paper Tape Set consists of a Typewriter, Typewriter Control Unit, Paper Tape Punch, and Paper Tape Reader. These items, described in detail in the SS1A Operation and Maintenance Manual, Volume IV, Part One, were designed and first fabricated for Philco under subcontract by Kleinschmidt Laboratories, Incorporated (KLI), as a follow-on to a prior KLI developmental contract with the Signal Corps. Procurement under this contract was essentially for the same equipment, including the improvements and modifications made on earlier models.

The major difference between the SS1A Paper Tape Set and the one provided with the developmental BASICPAC is that the latter conforms with the earlier version of the FIELDATA Equipment Intercommunication Characteristics (Green Book), while the SS1A Paper Tape Set conforms with the 1 April 1959 Revision (Orange Book). The typewriter unit is the one most affected by this change. Keyboard entry mode of operation, character parity error detection and indication, and stop on parity are all added features. A few of the typewriter codes were also modified.

The Kleinschmidt FIELDATA Paper Tape Set has shown a marked improvement in performance since October of 1961, after being excessively difficult to use productively for the previous year and a half. The basic reason for the improvement in performance has been the effort put forth in continuous modifications by Kleinschmidt, subsequent to October, in rectifying and retrofitting any and all design problems in the equipment, in addition to the constant field experience, engineering guidance and constant evaluation and test provided by Philco Engineering.

4.7.2 Paper Tape Reader

The first piece of equipment modified under the above-mentioned KLI-Philco redesign program was the Paper Tape Reader. Through the period of October, November and early December 1961, KLI undertook extensive testing and mechanical redesign. Philco evaluated these redesigns as they became available, and completely re-evaluated all electronic circuits. At the end of this period, it was found that the new reader would operate satisfactorily over the entire range of signal conditions encountered in use with the BASICPAC computer. Line voltage variation tests and some high and low temperature tests were run, all very successfully. A review of the significant changes made in the reader is given below:

1. The second drive sprocket and drive sprocket shaft was removed.
2. The idler gear and idler gear assembly were removed.
3. The stepper arm, stepper wheels and associated hardware were modified to provide reliable operation.
4. The remaining tape drive sprocket wheel was modified.
5. A tape width setting device for the three different standard tape widths was provided.
6. Modifications in adjustment procedures, tolerances, clearances and spring tensions were made.
7. A delay circuit was added for use in conjunction with the ready line to provide sufficient time for electromechanical recovery in rapid stop-start operation.
8. The strobe pulse generating circuit was modified for more reliable operation under temperature and voltage variation.
9. The web amplifier was modified to improve electrical characteristics.
10. The photocell assembly was revised to include factory alignment and permanent cell location in the cell block. Height adjustments were made considerably easier.
11. A number of other minor changes were made to improve long term reliability.

These items have given marked improvement to an item which has for so long been the weak link in the BASICPAC FIELDATA systems. Both systems users and Philco programmers have, for the first time, been able to make continuously productive uses of BASICPAC equipments. These encouraging statements do not mean that there are no problems left with the reader, but rather that those which remain are of a relatively minor improvement-type nature; items which might more profitably be corrected as part of any follow-on or production run of these equipments at KLI. Two of the somewhat annoying types of problems still existent on the reader are occasional paper tape breakage in the tape handling mechanism and difficulty in obtaining or replacing the reader lamp.

KLI has supplied Philco, and subsequently Philco has supplied the Signal Corps, with two new, up-to-date readers at no charge, and has also supplied personnel to assist in testing these units on the computer. After the successful completion of these tests, these new readers were used as field substitutes on the BASICPAC Serial Numbers 6 and 7, while the old readers were returned to the factory for retrofit. These old readers have now been updated and returned to the field, and all appear to be operating satisfactorily, with no more than routine maintenance.

4.7.3 Paper Tape Punch

The Paper Tape Punch has been operating reasonably well for the past year, and there has not been any major rework or redesign recommended by Philco except for a few items, perhaps applicable to possible production equipment at some later date. The Punch has passed all tests to which it has been subjected. However, previous problems in the Reader and/or Typewriter have limited some of the Punch testing to date.

4.7.4 Typewriter and Typewriter Control Unit

1. Typewriter

After satisfactory operation of the Reader and Punch were obtained, the major Paper Tape Set difficulties then lay in the Typewriter and Typewriter Control Unit. The problems have been divided into two areas; those associated with reliable operation at room temperature and normal conditions, and those associated with extreme environmental conditions. KLI retrofitted a large number of changes in the Typewriter which then permitted reliable operation under normal conditions and ease of maintenance of the

equipment. These changes included the major items listed below. A complete evaluation was made by Philco as the modified equipment became available.

- a. Redesign of the tabulator clutch mechanism
- b. Tabulator set and stop mechanism rework
- c. Power roll bearing improvement
- d. Mode switch mechanism rework
- e. Rework of sliders, solar cells and light source, including supplying the light source with a DC voltage
- f. Improvement of carriage return mechanism.

Insofar as the environmental problems are concerned, it is generally felt that no available typewriter (including KLI, Flexowriter or IBM) could meet all of the stringent requirements listed in SCL-1943A and accordingly, in Philco's related specification 9S 3331A. Philco has requested and received waivers from the Signal Corps for the Typewriter environmental extremes. KLI has tested one Typewriter to destruction while evaluating its operation under high humidity. However, certain improvements can be made in existing equipment to provide for operation over a reasonably wide range of conditions. Two areas cause excessive problems: "sand and dust" and "high humidity", especially when combined with high temperature. Additional evaluation has determined that the redesigned KLI Typewriter equipment will withstand one complete humidity cycle per MIL-STD-170A.

2. Typewriter Control Unit

The Paper Tape Set Typewriter Control Unit, while not encountering as many difficulties as the Typewriter, had also been a source of trouble. The two principal problems have been in the mode control relays and the cooling fan. The relays lie in the path of the cooling air stream and are extremely sensitive to dust and dirt deposits on the contacts. KLI has designed and supplied a relay dust cover which has been installed in all units. This helped considerably, although in future design it is recommended that either sealed relays or solid state switching be used. The cooling fans experienced many failures, principally due to rapid deterioration of brushes while in operation. Some units had a life as short as 10 hours, and none exceeded 200 hours. KLU supplied new motors for replacement at no charge, while procuring and testing a new design fan. This new fan has been successfully tested for over 1000 hours and has also been retrofitted in the two (#6 and #7) control units. It should also be noted that the new fan is a great deal quieter than the original unit supplied.

4.7.5 Summary

The re-evaluation and re-working of the KLI FIELDATA Paper Tape Set has progressed very satisfactorily (although slowly at times) and the major operational problems have been solved. At this time, therefore, the KLI Paper Tape Set appears to be the best equipment readily available for field operation in conjunction with FIELDATA equipments. Further R and D effort would be highly desirable to enable at least this part of the FIELDATA systems peripheral equipment to realize the full presently specified requirements.

SECTION 5 CONCLUSIONS

The BASICPAC S109 Shelter System delivered to USAERDL fulfills the requirements of SCL-1943A and of Contract DA-36-039-SC-85146 and all modifications thereto. This equipment is described fully in the SS1A Operation and Maintenance Manual, Volumes I through V, which were also delivered under this contract. This final report reviewed and summarized the development and fabrication of this computer system, with the following general conclusions.

The work performed under this contract has successfully accomplished an adaptation of existing, proven logic, circuit and mechanical design of a military processor and computer for automatic data processing (Basicpac #1) to the requirements of a sheltered automatic data processing subsystem for field artillery applications.

Accomplished in this program have been the expansion of the original system to include a second 4096 word core Memory, expansion of the Communications Converter to include a full seven channels and provision for the addition of a second Input/Output Converter. Included in this system are certain modifications of logic, circuit and mechanical design where these are indicated from the experience gained in assembling, testing and debugging the BasicPac Serial #1.

Special auxiliary equipment requirements for the subsystem resulted in the development of the following, under Philco subcontracts:

- a. The modification of the Digital Data Terminal AN/TYC-1; to develop the model XC-3 which includes operation at a 75 bit per second transmission rate.
- b. The design of the Message Entry Device to facilitate rapid transmission of coded messages from an observer to the central processor, and
- c. The design of the Forward Area Display Unit to provide rapid display of coded information from the central processor at a remote location.

The complete subsystem including all peripheral equipment has demonstrated good operation both at Fort Monmouth, New Jersey and at Fort Huachuca, Arizona.

SECTION 6 RECOMMENDATIONS

It has been concluded that the SS1A Shelter System Complex meets the contractual requirement satisfactorily. After completion and delivery of a successful working model, many ideas for improvement are brought to light. Some of the more significant suggestions are presented here for consideration:

- a. Reduce number of card types.**
- b. Increase memory capacity from 4K to 8K in the same size unit.**
- c. Expand Communications Converter from 7 real time input/output channels (including 1 limited interrupt) to 8 real time limited interrupt channels.**
- d. Expand Input/Output Converter from 7 to 16 channels (devices) with up to 4 simultaneous channel operations.**
- e. Incorporate a Search Unit operating in conjunction with the input/output converter and stored information input device.**

One of the most useful changes, from the processor logistic support and maintenance viewpoint, would be the reduction in the number of card types required. An integral part of this modification would be a logical re-partitioning of the processor. An advantage accruing from this would be inclusion of logical changes to expand the basic capabilities of the computer. Expanded order catalogue and increased index register capacity are immediately brought to mind. At the same time improved logic circuit combinations could be incorporated which would increase reliability at no additional cost.

Another modification, which would greatly increase the capability of the processor, is the conversion of the existing 4096 word core memory to an 8192 word unit occupying the same volume. Advantages are self-evident in ability to handle more complex programs and greater capability of processing data from input/output equipment.

Expanded I/O capability is a highly desirable feature for increasing the scope of the data processor for handling logistic and fire control problems.

A modified BasicPac incorporating the above items would be an extremely powerful and worthwhile addition to the Army's Automatic Data Processing Systems.

SECTION 7 PERSONNEL

The Philco subsystem SS1A development effort was under the general supervision of Dr. S. D. Wanlass, General Manager of the Computer Division; Mr. J. Colocousis, then Director of Computer Engineering; and Mr. S. M. Berkowitz, Manager of the Military Computer Engineering Department.

The list below identifies the key direct-charging engineering personnel on the SS1A project, and indicates the amount of time they applied to this program.

| <u>Name</u> | <u>Title</u> | <u>Manhours</u> |
|---------------------------------------|--------------|-----------------|
| <u>Section Managers</u> | | |
| W. Bradley | | 125 |
| G. Frater | | 338 |
| F. LaVerghetta | | 965 |
| H. Mellinger | | 451 |
| F. Spera | | 873 |
| <u>Engineering Group Supervisors</u> | | |
| R. Atkinson | | 923 |
| F. Clark | | 44 |
| R. Norwood | | 10 |
| H. Nyser | | 298 |
| A. Walberg | | 255 |
| <u>Senior Engineering Specialists</u> | | |
| J. Chapline | | 15 |
| J. Glaser | | 8 |
| <u>Engineering Specialists</u> | | |
| W. Endries | | 23 |
| M. Freeman | | 1497 |
| J. Selinsky | | 7 |
| F. Simmons | | 470 |
| F. Ungerman | | 1178 |

| <u>Name</u> | <u>Title</u> | <u>Manhours</u> |
|--------------|--------------------------|-----------------|
| | <u>Project Engineers</u> | |
| G. Bekampis | | 203 |
| D. Biles | | 1372 |
| G. Forman | | 1114 |
| H. Glaser | | 3520 |
| H. Pacion | | 27 |
| M. Stad | | 106 |
| J. Standeven | | 634 |
| E. Whitley | | 311 |
| | <u>Senior Engineers</u> | |
| R. Gammill | | 551 |
| R. Grossman | | 3 |
| N. Holloway | | 48 |
| D. Jaffee | | 637 |
| I. Johnston | | 2612 |
| G. Monti | | 462 |
| R. Sauer | | 10 |
| F. Simmons | | 2229 |
| A. Tedesco | | 736 |
| L. Wellons | | 125 |
| R. Wetter | | 1523 |
| J. Zimmerman | | 1995 |

APPENDIX A
MESSAGE ENTRY DEVICE SSIA
(MED)

Final Report
by
STELMA, Inc.

Report No. 4

Contract No. 804318

Final Report

25 October 1960 to 1 April 1962

**DEVELOPMENT OF
MESSAGE ENTRY DEVICE SS-1A**

Philco Specification 98-3332

Signal Corps Technical Requirement SCL-4191

OBJECT:

**The development of a tactical Message Entry
Device (MED) for data-processing systems.**

**Report Prepared by:
H. Robbins**

This publication supersedes Report Number 4

(Final Report) dated 30 December 1961.

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1. Purpose

The purpose of this project is to develop, construct, and test Message Entry Device SS1A (abbreviated as MED) for use in an automatic data-processing system for field artillery. Portable and highly reliable for tactical application, the MED is battery powered and utilizes solid-state devices exclusively. Specifications covering the equipment are listed in Signal Corps Specification SCL-4191 and Philco Specification 98-3332, 16 September 1960.

The MED is used, by a forward observer, for entering messages into a remotely located central processor. In the field-artillery application, typical messages would be: initial fire request, subsequent fire request, or surveillance data.

Data is entered in the MED by setting each of 21 switches to one of ten positions. (The meaning assigned to each switch and switch position is described in Philco Specification 98-3332, pages 19-27.) The message entered is displayed on the front panel so that it may be checked by the operator. Once checked, the message is transmitted, over voice channels, as a frequency-shift tone at a 75-bps rate; it is received by an AN/TYC-1 (XC-3) receiver and converted to Fieldata levels for data processing.

The project is divided into three phases:

Phase 1. Design

Phase 2. Construction and Test of MED #1

Phase 3. Construction and Test of MED #2

2. Abstract

a. Development of the Message Entry Device/SS1A was initiated on 25 October 1960.

b. Logical design was completed by 16 January 1961.

c. Electronic design was completed by 25 April 1961.

d. Mechanical design was completed by 25 July 1961.

e. Construction of the first MED began on about 1 August 1961. This was delivered on 18 October 1961.

f. Construction of the second MED began on about 1 September 1961; the second MED was delivered on 14 December 1961.

g. Retrofitting of the first MED was begun on 15 December 1961. Trouble had been experienced with the Message Entry switches. Improvements had been made in the switches on the second MED; the improved switches were installed in MED #1. The unit was redelivered on 16 February 1962. Further modifications were again found necessary and the unit was returned for rework and adjustment for final delivery by October, 1962.

3. Reference Material

a. PUBLICATIONS. For information on the MED, refer to the following:

(1) STELMA Technical Proposal for a Tactical Message Entry Device, 6 September 1960.

(2) Philco Specification for Message Entry Device SS1A 9S-3332.

(3) Signal Corps Specification SCL-4191.

(4) Final Design Plan for Digital Data Terminal AN/TYC-1 (MOD), January, 1961.

(5) Fielddata Equipment Intercommunication Characteristics, 1 April 1959, revised 1 August 1959.

(6) Final Design Plan for Message Entry Device SS1A, 16 January 1961.

(7) Test Program for Message Entry Device SS1A, 24 March 1961.

b. CONFERENCES. During the development of the MED, the following seven conferences were held.

(1) A conference at Philco, at Willow Grove, on 3 November 1960, was attended by:

STELMA

Dr. N. Kramer
Mr. B. Krauss
Mr. S. Schneider

Philco

Mr. F. Laverghetta
Mr. H. Schwartz
Mr. H. Glazer
Mr. F. Spera

The following aspects of the MED were discussed:

(a) the possibility of initiating some changes in the specification,

(b) the preparation of the final design plan,

(c) other technical aspects of the MED.

3. Reference Material

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- (2) Philco Specification for Message Entry Device SS1A-98-3332.
- (3) Signal Corps Specification SCL-4191.
- (4) Final Design Plan for Digital Data Terminal AN/TYC-1 (MOD), January, 1961.
- (5) Fielddata Equipment Intercommunication Characteristics, 1 April 1959, revised 1 August 1959.
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Mr. S. Schneider

Philco

Mr. F. Laverghetta
Mr. H. Schwartz
Mr. H. Glazer
Mr. F. Spera

The following aspects of the MED were discussed:

- (a) the possibility of initiating some changes in the specification,
- (b) the preparation of the final design plan,
- (c) other technical aspects of the MED.

(2) A conference at Philco, Willow Grove, on 1 December 1960, was attended by:

STELMA

Dr. N. Kramer
Mr. S. Schneider
Mr. B. Krauss

Philco

Mr. F. Laverghetta
Mr. H. Schwartz
Mr. H. Glazer
Mr. F. Spera

In a discussion of MED design, it was decided that further study would be required before a detailed discussion of the problem of panel lighting could be concluded.

(3) A conference at STELMA, Incorporated, on 10 February 1961, was attended by:

STELMA

Dr. N. Kramer
Mr. S. Schneider
Mr. B. Krauss

U.S.A.S.R.D.L.

Mr. J. Cox
Mr. A. DeRose

Philco

Mr. H. Schwartz
Mr. H. Glazer

Design of the electronics, and design of the mechanical parts were discussed.

(4) A conference at STELMA, Incorporated, on 25 April 1961, was attended by:

STELMA

Dr. N. Kramer
Mr. B. Krauss
Mr. S. Schneider
Mr. E. Robbins

U.S.A.S.R.D.L.

Mr. J. Cox

Philco

Mr. H. Glazer
Mr. F. Spera

At the conference, the progress of the MED program at STELMA, Incorporated was discussed. Additions incorporated into the test program, at this time, include a drop test and a 100-hour life test.

(5) A conference at STELMA, Incorporated, on 20 June 1961, was attended by:

STELMA

Mr. R. Plouffe
Dr. N. Kramer
Mr. H. Robbins

Philco

Mr. W. Livingstone
Mr. H. Glazer

A revised delivery schedule as well as changes in the test plan were discussed.

(6) A conference at STELMA, Incorporated, on 27 June 1961, was attended by:

| <u>STELMA</u> | <u>U. S. A. S. R. D. L.</u> | <u>Philco</u> | <u>U. S. A. P. G.</u> |
|----------------|-----------------------------|---------------|-----------------------|
| Dr. N. Kramer | Mr. J. Stout | Mr. H. Glazer | Capt. Enslow |
| Mr. H. Robbins | Mr. J. Cox | Mr. V. Sontag | |

The MED prototype was demonstrated, and its operation as well as the delivery status was discussed.

(7) A conference at STELMA, Incorporated, on 18 August 1961, was attended by:

| <u>STELMA</u> | <u>Philco</u> |
|----------------|------------------|
| Dr. N. Kramer | Mr. J. Zimmerman |
| Mr. B. Krauss | Mr. S. Caldwell |
| Mr. H. Robbins | Mr. F. Spera |

Delivery status and quality control consideration of the MED were discussed.

(8) A conference at Philco, Willow Grove, on 12 July 1962, was attended by:

| <u>STELMA</u> | <u>Philco</u> |
|----------------|----------------------|
| Dr. N. Kramer | Mr. H. Alabrodzinski |
| Mr. R. Plouffe | Mr. R. Atkinson |
| | Mr. S. Berkowitz |
| | Mr. W. Freas |
| | Mr. H. Glazer |
| | Mr. C. Pafort |
| | Mr. C. Sommer |

Problems with MED #1 were discussed as well as Stelma's further retrofit of this unit.

4. Factual Data

a. GENERAL.

(1) The Message Entry Device (MED) is to be used with automatic data-processing for the field artillery. Data entered into the MED, by manually setting a group of 21 switches, is transmitted as a frequency-shift tone (at 75 bps) over a voice-frequency channel. It is received by an AN/TYC-1 (XC-3) receiver and converted to Fielddata levels for data processing.

(2) The following paragraphs describe system application as well as the development of MED:

(a) logical, electrical, and mechanical design, and

(b) testing.

b. SYSTEM APPLICATION. Figure 1 shows a typical observer-to-computer data link, using the MED.

(1) Because the MED is to be used in addition to, and not as a replacement for, oral reports for the forward observer, the observer will be equipped with a handset (in addition to the MED). A type-U79/U connector is supplied for connecting the handset into the MED; for oral reporting the handset is used in the conventional manner. A notch filter in the MED permits simultaneous transmission of voice plus data. The notch filter deletes, from the voice channel, the signal components in the frequency band required for data. The notch is not noticeable to a listener at the receiving station. The combined message (for either voice or data) is transmitted via a voice channel, which is generally radio but may be a wire line. At the receiving station a filter separates the voice and data, so the data goes to an AN/TYC-1 (XC-3) Receiver where it is converted to 8-bit Fielddata characters for application to automatic data processing equipment.

(2) The following special control characters are required by AN/TYC-1 (XC-3) and the data-processing equipment:

(a) Two synchronizing characters (01001111) transmitted at the start of message for frame-locking the AN/TYC-1 (XC-3) terminal.

(b) An end-of-message character for computer use.

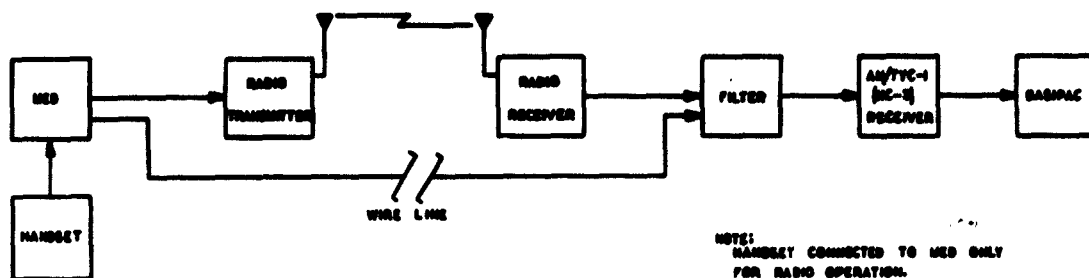


FIGURE 1
MESSAGE ENTRY DEVICE 881A, SYSTEM APPLICATION
BLOCK DIAGRAM

(3) The MED message length may be 12, 18, or 24 characters, depending on the amount of new data to be reported. A special skip character (10111111) is transmitted whenever the message is fewer than 24 characters.

(4) A one to three second delay, generated between the time the MED is operated and the time when transmission occurs, permits radio transmitter warm-up and stabilization.

c. LOGICAL DESIGN.

(1) Message and Word Structure. MED message and word structure are defined in Tables 1 and 2, respectively.

Table 1. MED MESSAGE STRUCTURE

| Character | Function | Remarks |
|-----------|----------------------|---|
| 1, 2 | AN/TYC-1 (XC-3) SYNC | Always transmitted |
| 3 | Data or skip row 1 | Data when characters in row are transmitted, skip row when characters in row are skipped. |
| 10 | Data or skip row 2 | |
| 17 | Data or skip row 3 | |
| 4-9 | Data row 1 | Transmitted when format switch in T or B position, skipped in N position. |
| 11-16 | Data row 2 | |
| 18-23 | Data row 3 | |

Table 1. MED MESSAGE STRUCTURE (Cont'd)

| <u>Character</u> | <u>Function</u> | <u>Remarks</u> |
|------------------|-----------------------|---|
| 24 | End of Message Signal | Occurs at end of each message. May occur as character 12 if 2 rows are skipped, as character 18 if row is skipped, or as character 24 if no rows are skipped. |

Table 2. MED WORD STRUCTURE

| <u>Character</u> | <u>Function</u> | <u>Remarks</u> |
|------------------|-----------------|--|
| 1 | Parity | Odd parity is used. |
| 2 | Control | "1" data, "0" skip row or end of message. |
| 3, 4 | Format Control | Format switch on T - "1" Format switch on B - "0" |
| 5, 8 | Data | Ten out of sixteen code. |

(2) System Block Diagram. A block diagram of the MED is shown in figure 2.

(a) A stable 75-pps oscillator, the system clock, supplies clock pulses that advance the 8-stage bit counter, which pulses each of eight lines sequentially. A coding matrix is wired for the MED code. The bit-counter output drives the matrix, where outputs are serial sequences of pulses; each sequence is one of the 23 different characters available (20 Data, 1 Sync, 1 Skip Row, 1 End of Message).

(b) The 21 Message Select switches, which permit selection of the desired characters from the matrix, are enabled sequentially (each for one character interval) by the 24-stage character counter. Character timing is derived from one cycle of the bit counter. The AN/TYC-1 (XC-3) sync character and the end-of-message character (which are independent of the message) are controlled directly by the character counter. The



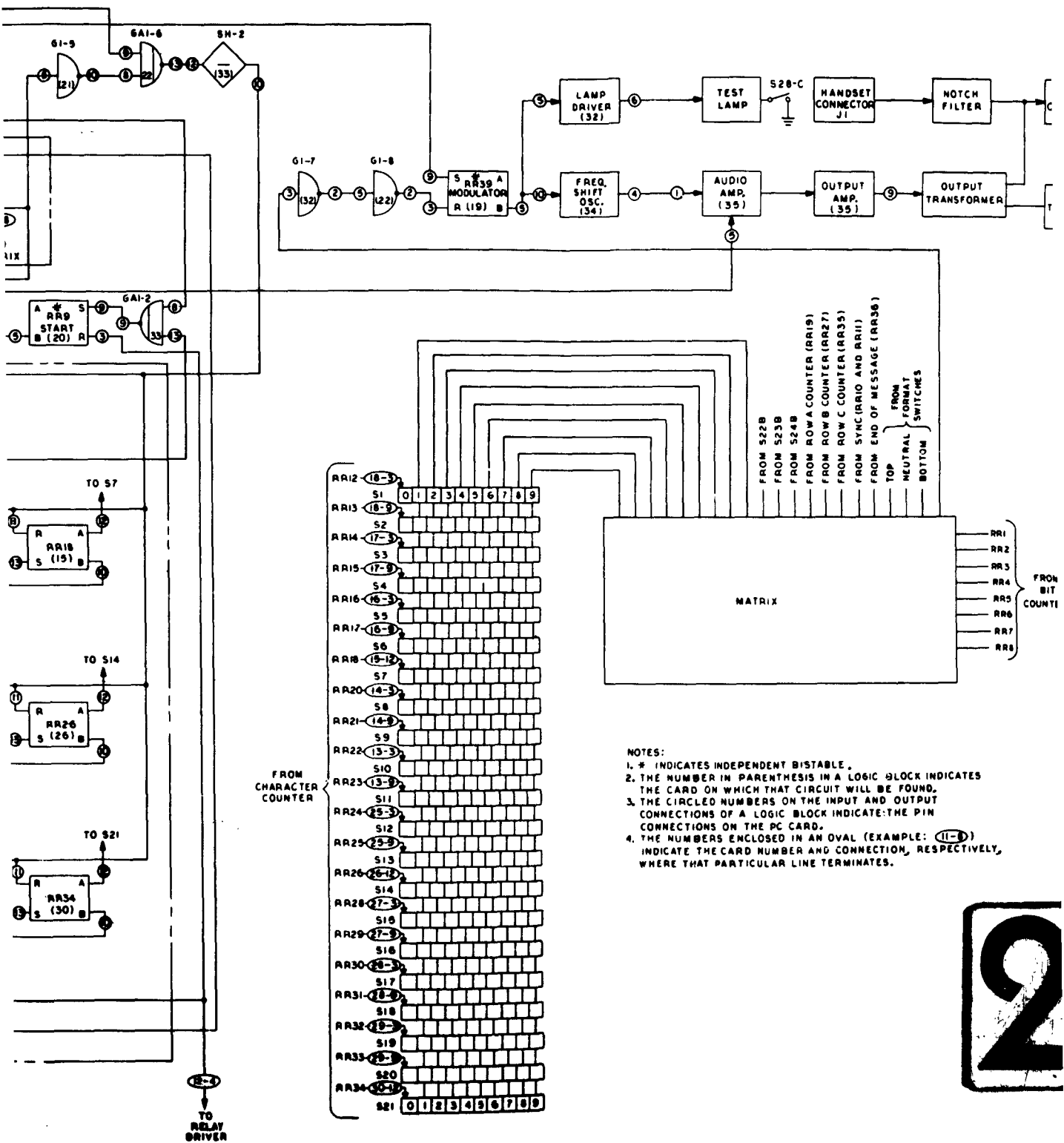


FIGURE 2
MESSAGE ENTRY DEVICE SS1A, COMPLETE LOGIC DIAGR

Format Control switches, under control of the row counter, select bits 1, 2, 3 and 4 of each character (and select the skip-row character if it is required). The selected matrix outputs then trigger a modulator bistable (RR 39), which controls the frequency-shift oscillator. The modulator bistable is set by the output pulses from the coding matrix, and is reset at clock time (several microseconds before the coding matrix output occur). The modulator bistable is therefore set for one bit interval for every matrix output pulse.

(c) Data transmission is initiated when the Transmit pushbutton is operated. The pushbutton energizes a relay which applies power to the +6 volt and 1.5 volt bus and excites the monostable. With power applied, the 75-pps clock and the frequency-shift oscillator operate. Both the bit counter and the character counter, however, are completely reset, and no outputs are generated by them. At the end of one to three seconds, the monostable returns to its stable state and generates a start pulse. The start pulse sets the first character counter bistable (RR 10). This in turn sets the start bistable (RR 9) at the beginning of the next clock pulse. The first bit counter bistable (RR 1) is set when the start bistable is set.

(3) Counter Design.

(a) BIT COUNTER. A logic diagram of the bit counter is shown in figure 3. Eight bistables are required, each having a set and reset input, and a single output (the output is +6 volts when reset, and 0 volt when set). Negative clock pulses are used for resetting; a bistable is set by a positive transition at the set input. When power is applied, all stages come on in the +6 volt or reset state. When the start pulse occurs, gate GO-4 pulls the first stage output to 0 volt, thereby setting it. The next clock pulse resets the first stage. The positive transition from the first stage then sets the second stage. The counter continues to count in this manner.

(b) CHARACTER COUNTER. Operation of the character counter is similar to that of the bit counter (figure 3).

(1) Clock pulses are derived from the last stage of the bit counter; the character counter therefore advances every eight bits.

(2) Character counter stages 1 and 2 control generation of the AN/TYC-1 (XC-3) Sync character. Stages 3 to 9 control the first seven data characters (row 1).

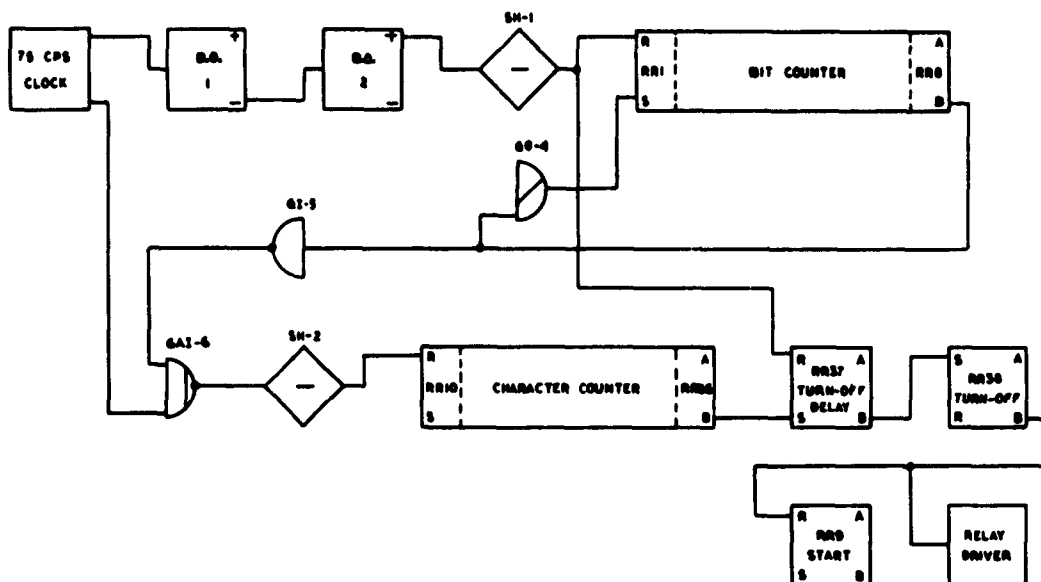


FIGURE 3
MESSAGE ENTRY DEVICE SS1A, TIMING LOGIC BLOCK DIAGRAM

(3) The stage-3 output goes to the row-1 Format Control switch. If the switch is in the "T" or "B" position, indicating that row 1 is to be transmitted, stage 4 is set after stage 3 is. If the switch is in the "N" position, stage 10 is set after stage 3 is; characters four to nine have been skipped. Notice that stages 3, 10, and 17 are set regardless of Format Control switch positions. This permits them to control either the first data character of the row, or the skip-row character. Format control bistables (or row counters), shown below stages 5, 12, and 19, are set when any counter in their respective rows is set. They are reset when the row is completed.

(4) The end-of-message character bistable is set when the format control bistable for row 3 is reset. At this time row 3 has been completed, and the end-of-message character is generated. After the end-of-message character has been transmitted, the turn-off sequence is initiated. At the end of the last bit of the message, the turn-off delay bistable is set, and then the turn-off bistable is set. This activates the relay driver, removing all power from the MED.

(4) Coding Matrix. A schematic diagram, useful for explaining the logic of the Coding Matrix, is shown in figure 4.

(a) Inputs from the bit counter, present on points 1 through 8, are differentiated by the input capacitors. Pulse operation minimizes power consumption in the matrix. Only negative pulses go through the diodes. Coded pulse trains appear on each of the fourteen vertical lines.

(b) The output line on the extreme left generates the AN/TYC (MOD) sync character (01001111). The pulses pass through a coupling capacitor to a resistor bias network and output diode. The bias network is controlled by the first two stages of the character counter. If either stage is set (at zero level) the output diode will be biased at 0 volt, so that it passes negative pulses to the modulation bistable. If neither stage is set however, the diode will be biased to +6 volts; consequently it can pass pulses from the sync-character line.

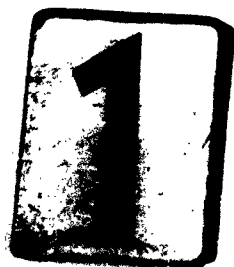
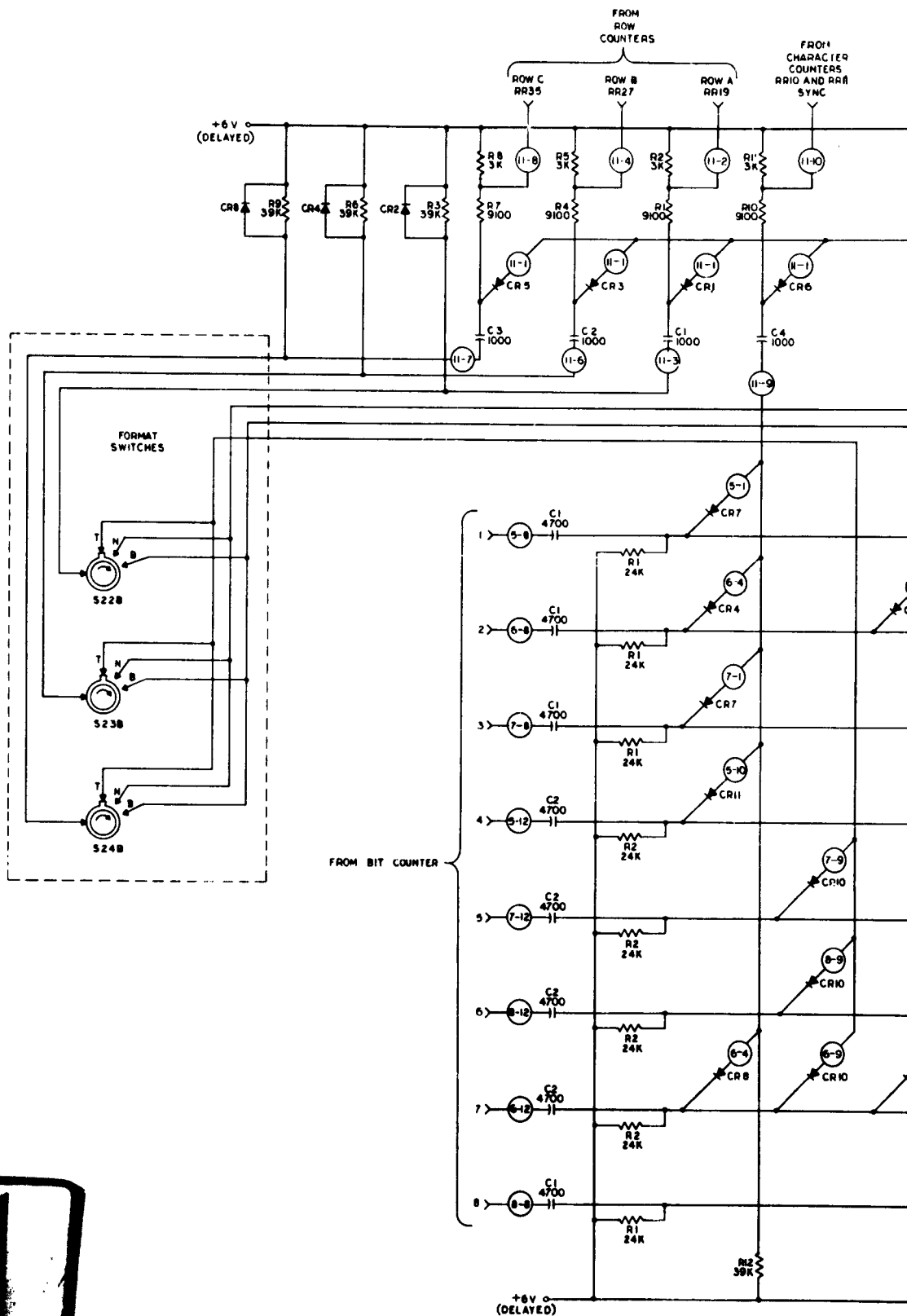
(c) Other output lines from the matrix work in a similar manner. Each output line goes to a bias network and diode. Each bias network is tied to one of the ten contacts on the Message Selector switches. The switch contacts are all wired in parallel. The pole from each switch is tied to the appropriate stage in the character counter through an isolating diode. The inserted switch setting provides the means where the appropriate character-counter stage can be tied to any one of nine matrix output lines. When the stage is set, it will pass the pulse train from that line through the output diode.

(d) The character counter and Message Selector switches control bits 1, 5, 6, 7, and 8. Bits 2, 3, and 4, the Format and Control bits, are under control of the Format switches and format or row counter. Control of these three bits is similar to that of the other bits. The skip-row character is also controlled by the Format switches and row counter. The end-of-message character is controlled directly by stage 24 of the character counter, in a way similar to that in which the synchronizing characters are controlled.

d. ELECTRICAL DESIGN.

(1) General. The MED/SS1A includes both digital and audio circuitry. The former is used for generation of the message, and the latter is used for generating and amplifying the frequency-shift signal.

(2) Design Techniques. Worst-case design techniques were used throughout the MED. Each different circuit was fully temperature tested at least twice (at two different stages of design); some circuits were tested



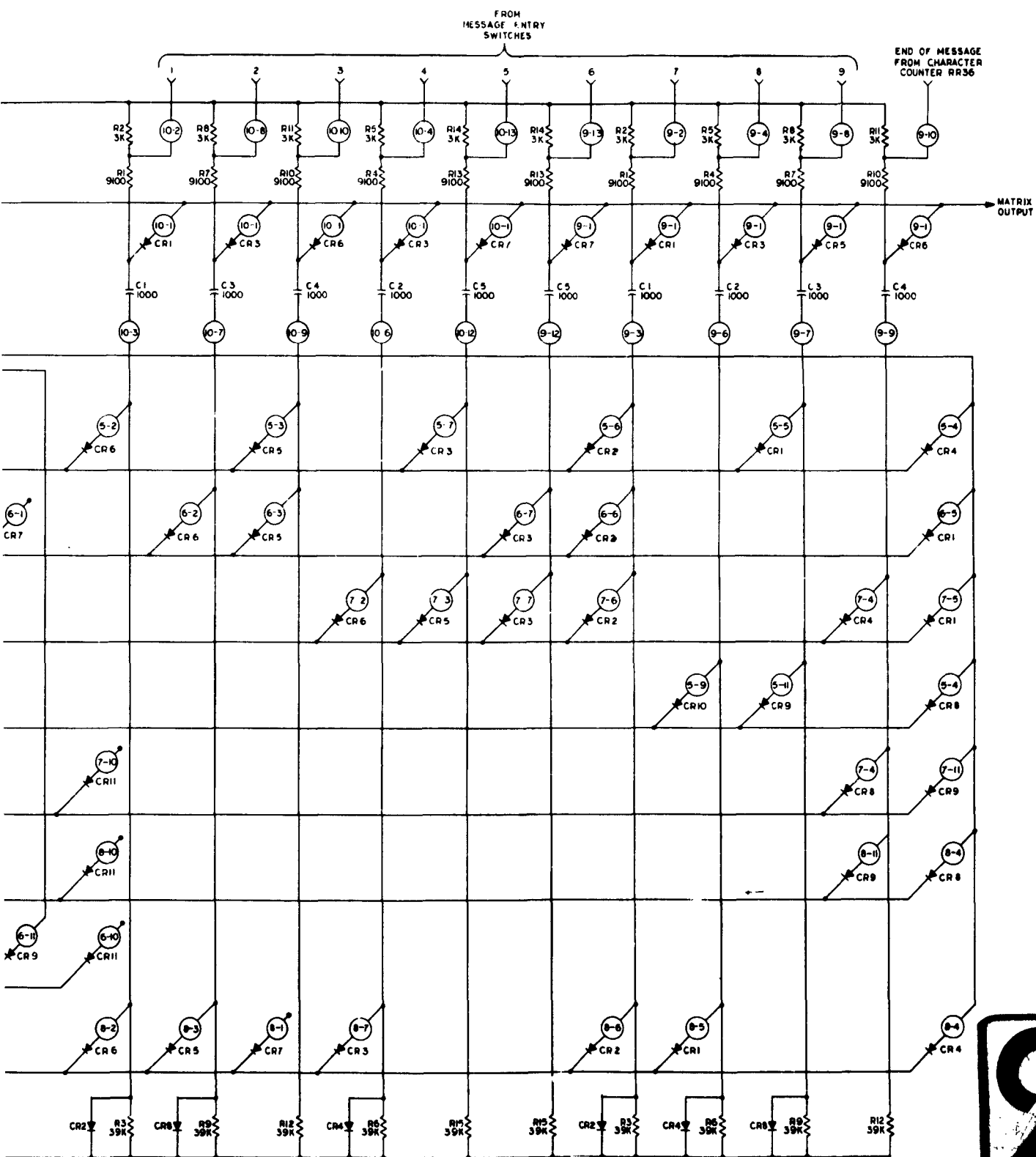


FIGURE 4
MESSAGE ENTRY DEVICE SS1A, MATRIX SCHEMATIC DIAGRAM

many times at temperature extremes. Interconnection compatibility was tested under temperature extremes, at two different levels of development before final assembly of deliverable units. Both deliverable MED's passed temperature and life tests before shipment.

(3) Semiconductor Data. Only three different types of transistors are used in the MED: USN2N388, USAF2N167A, and USAF2N404.

(a) The USN 2N388 is a general-purpose germanium alloy NPN transistor, designed for switching applications. This type is used in all of the digital circuits and all but one of the audio circuits.

(b) The USAF2N167A, a grown-junction germanium NPN transistor, is used in the frequency-shift oscillator.

(c) The USAF2N404 is a general-purpose, germanium alloy PNP transistor, designed for switching applications. This type is used in most of the digital circuits as a complement to the USN2N388.

(4) Circuit Performance Data. All MED circuitry performed well within the specified limits under the specified test conditions. During development, however, two critical circuit problems were encountered, one being the frequency-shift oscillator, and the other, the 75-cps clock.

(a) FREQUENCY-SHIFT OSCILLATOR. Refer to Report No. 3 (Third Quarterly Program report) for an illustration and explanation of this circuit's operation. The nominal frequency of the outputs are 1232.5 cycles per second for data 0, and 1317.5 cycles for data 1 (with a specified tolerance of $\pm 1\%$). Under worst-case conditions as measured at the temperature extremes during acceptance tests, the data-0 frequency had limits of 1229 cps and 1241 cps, and the data-1 frequency had limits of 1309 cps and 1327 cps. Both data-0 and data-1 frequencies are well within the specified limits.

(b) 75-CPS CLOCK. The final circuit used in the MED is shown in figures 8 and 9 of the 3rd quarterly report (figure 8 shows the reed-controlled oscillator circuit, and figure 9 shows the astable multi-vibrator that is synchronized to the reed-controlled oscillator). The complete circuit generates timing waveform at a 75-cps rate. The required tolerance on the stability of this frequency is 0.1%. Under worst-case conditions as measured at temperature extremes during acceptance tests, the frequency of the worst of the two units varied from 74.9287 cps to 75.0712 cps; at room temperature under normal conditions the frequency was 74.9835.

e. MECHANICAL DESIGN.

(1) General. The MED is a hand-carried device intended for tactical operation. It is designed to meet or exceed the environmental requirements of Philco Specification 9S-3332, which includes vibration, shock, rain, watertightness, sand, dust, temperature, and altitude. The complete MED weighs about 13 pounds ready to operate, and it occupies 3/10 cubic foot of volume.

(2) Case. The MED (fig. 5) is packaged in a watertight fiber-glass case constructed in two halves. The lower half contains the operator's panel and the electronic components, and the upper half contains the batteries and the output cable for connecting the MED to a radio transmitter to insure watertightness, a rubber gasket is used where the two halves of the case meet. When the case is closed, this gasket is compressed by latches, to prevent the leakage of water. The radio connectors on the side of the case are watertight, being tested for 10-foot submersion.

(3) Operating Panel. When the case is opened, it reveals operating panel of the MED (flush with the top of the lower half of the case, fig. 6). A cable-retaining cover swings out on a hinge in the top half of the case to reveal the output cable and the battery compartment cover. Both the front panel and the battery compartment are rain-proof.

(4) Controls and Indicators. Table 3 shows the name, type, and function of the controls and indicators on the front panel of the MED.

Table 3. MED CONTROLS AND INDICATORS

| <u>Name</u> | <u>Type</u> | <u>Function</u> |
|--------------|--------------------------|---|
| POWER | 2-position rotary switch | Turns unit power on or off. |
| PANEL LIGHT | Pushbutton switch | When depressed, turns on panel lights. |
| OUTPUT LEVEL | 3-position rotary switch | Permits selection of output level: 0, -5, or -10 dbm. |

Table 3. MFD CONTROLS AND INDICATORS (Cont'd)

| <u>Name</u> | <u>Type</u> | <u>Function</u> |
|--------------------------|----------------------------|---|
| OPERATE - TEST | 2-position rotary switch | Establishes mode of operation: OPERATE position - connects MED output for normal operation. TEST position - connects TEST lamp and disconnects output, for go-no-go test. |
| TEST | Indicator lamp | Flashes according to data, during go-no-go test, to indicate normal operation. |
| TRANSMIT | Pushbutton switch | When depressed, starts operating cycle. |
| ZERO RESET | Mechanical rotary actuated | When actuated, resets all MESSAGE ENTRY switches to zero. |
| Format Switch A, B, C | 3-position rotary switch | Each defines format of information entered by its associated seven message-entry switches. T position - information indicated by heading at top of strip is transmitted. N position - MED transmits skip-row character. B position - information indicated by heading at bottom of strip is transmitted. |

Table 3. CONTROLS AND INDICATORS (Cont'd)

| <u>Name</u> | <u>Type</u> | <u>Function</u> |
|---|---|--|
| Message Entry Switches (three 7-switch rows) | Toggle-actuated, 10-position, rotary stepping switch | Each position of each switch sets a particular character of the message to be transmitted. * (When toggle is pressed towards operator, switch is advanced one position, when toggle is pressed away from operator, switch is reset to zero.) |

- * The character set by each switch position depends upon user's application; refer to Appendix for functions assigned for field-artillery application.

(5) **Message Entry Switches.** Twenty-one Message Entry switches are required, to enter the twenty-one possible characters which comprise a message.

(a) Each Message Entry switch is a 10-position, single pole, rotary switch that is toggle actuated; moving the toggle in one direction advances the switch one position at a time, and moving the toggle in the opposite direction resets the switch to zero.

(b) An indicator drum is an integral part of each Message Entry switch, the drum indicating the position to which the switch has been set (around the drum is inscribed the nomenclature for the particular character the switch represents). These drums are removable and interchangeable, a feature that makes the switches interchangeable.

(c) The Message Entry switch handle consists of a toggle which is spring-loaded in the center position (fig. 7). Moving the toggle in one direction steps the switch (by the pawl-ratchet arrangement shown) which in turn winds a coil spring. When the toggle is moved in the opposite direction, the detent is lifted from the ratchet, permitting the coil spring to reset the switch to zero; the detent may also be lifted by an eccentric rod passing over the switch. There are three such rods, each passing over one of the three rows of switches. The eccentric rods are turned by a linkage connected to the Master Reset lever. In this manner all the Message Entry Switches may be reset.

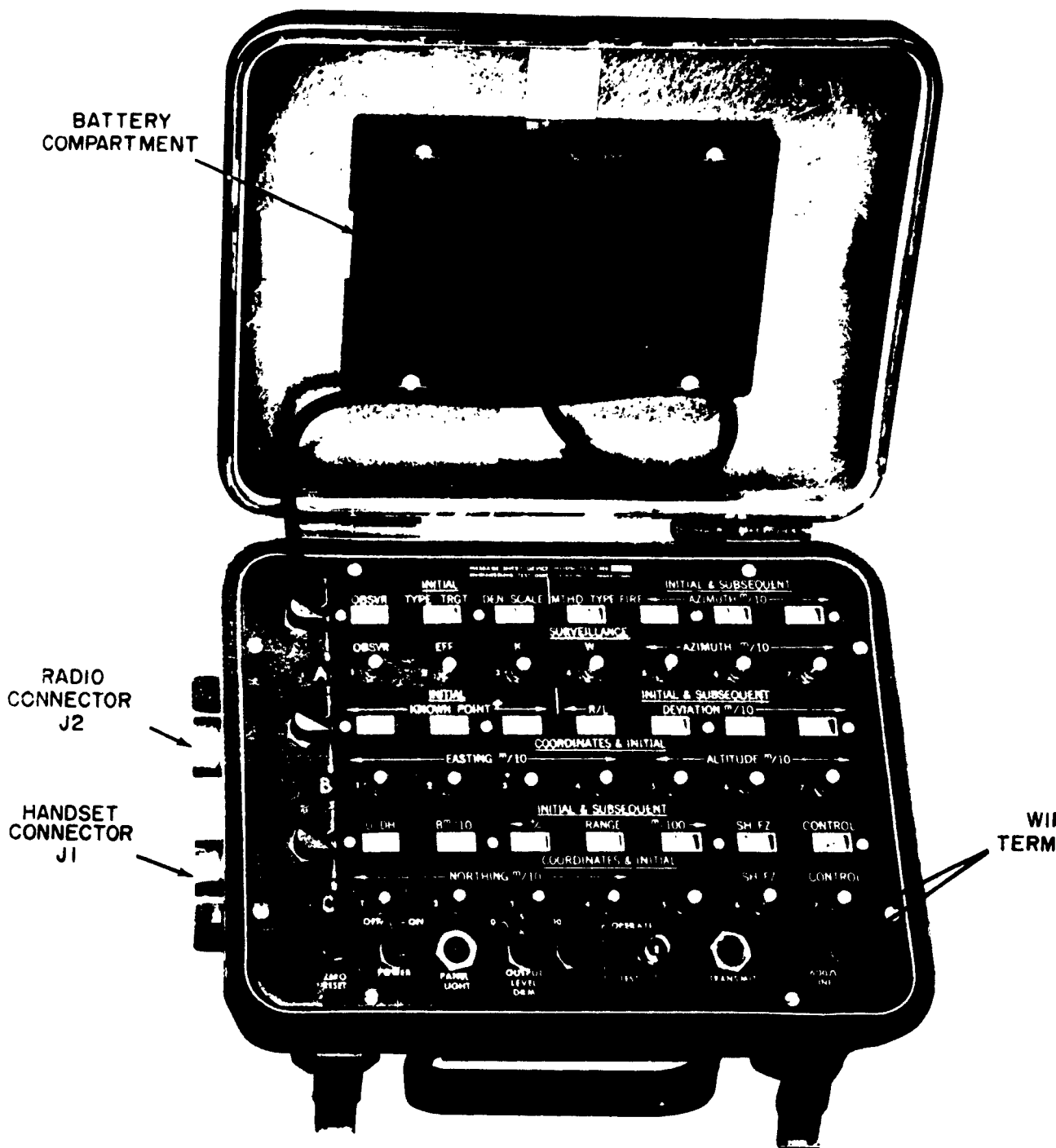
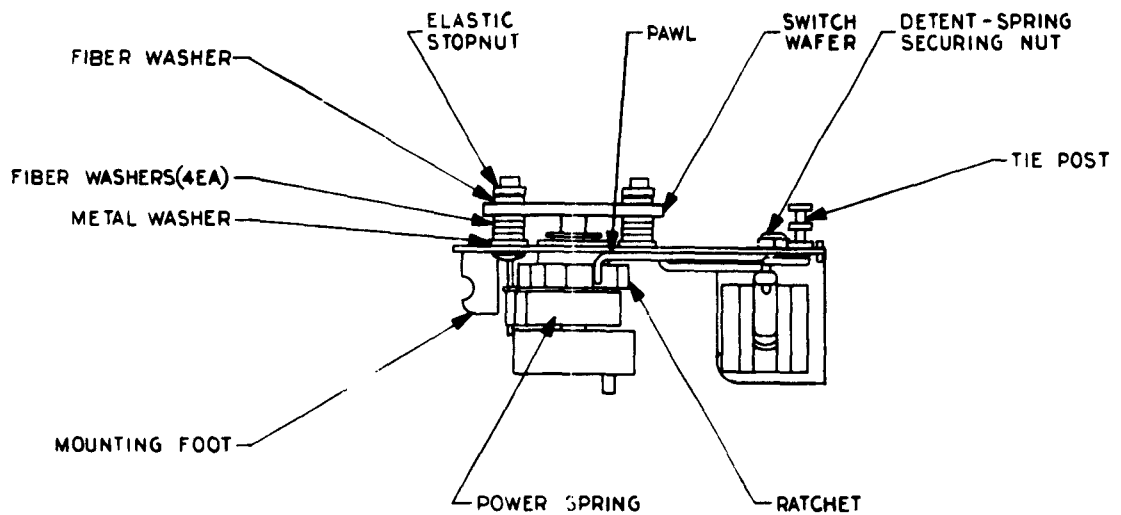
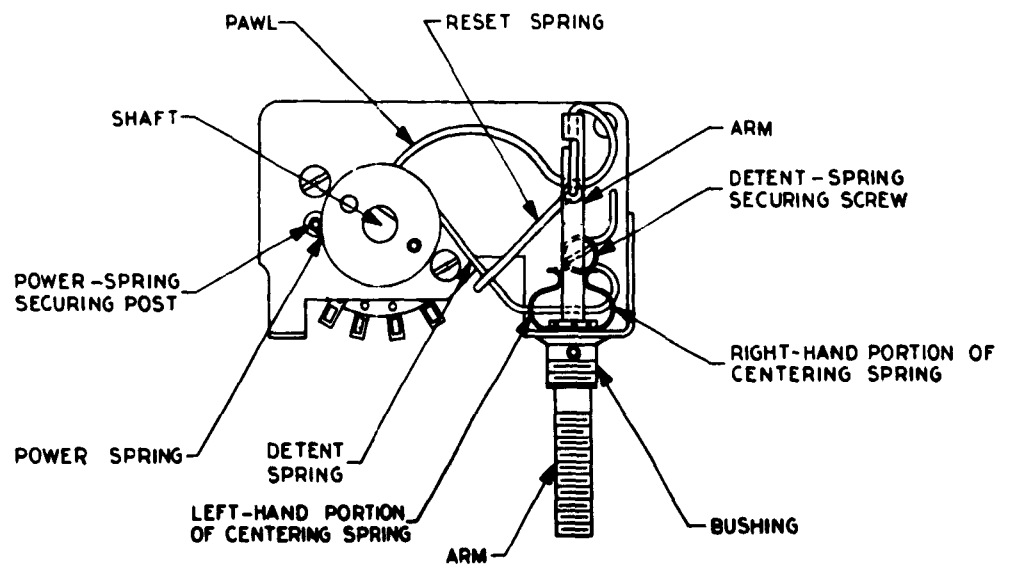


FIGURE 6
MESSAGE ENTRY DEVICE SS1A, FRONT PANEL



A. TOP VIEW



B SIDE VIEW



FIGURE 7
MESSAGE ENTRY DEVICE SS1A, MESSAGE ENTRY SWITCH
TOP AND SIDE VIEWS

(d) Experience with the Message Entry switch as delivered with the first MED revealed that a few improvements were desirable. First, a mounting foot was added (fig. 7) to the switch frame, opposite the bushing; this facilitates fastening the switch frame securely to the back of the MED front panel. Second, a dimple was formed in the switch frame to reduce bending; the dimple eliminates transient misalignment of the ratchet with the pawl and detent when the switch is operated. Third, the detent spring was silver-soldered to the frame, thereby eliminating the problem of detent-spring adjustment after the switch is manufactured. While these three changes improved switch reliability, further study could realize more improvement.

(e) The Appendix shows the Message Entry switch heading marking and the corresponding indicator drum marking. In cases where there are different markings on the drums per top and bottom mode operation, lettering for top mode is in black, and for bottom mode is in green on a white background. All other drum marking is in black on a white background.

(f) Electronic Components. Figure 8 shows the MED harness card containing all electronic circuitry. Included on the harness card are 36 plug-in printed-circuit cards, two relays, and one reed-oscillator control that plug into sockets, one 7-pin connector socket, and 10 other lead-mounted components. Table 4 lists the plug-in cards and their functions.

Table 4. MESSAGE ENTRY DEVICE PLUG-IN PRINTED-CIRCUIT CARD

| PC Number | Name |
|-----------|------------|
| 607 | BISTABLE I |
| 648 | MATRIX I |
| 649 | MATRIX II |



Table 4. MESSAGE ENTRY DEVICE PLUG-IN PRINTED-CIRCUIT CARDS (CONT'd)

| <u>PC Number</u> | <u>Name</u> |
|------------------|----------------------|
| 692 | BISTABLE II |
| 701 | RELAY DRIVER |
| 702 | BLOCKING OSCILLATOR |
| 703 | LAMP DRIVER |
| 704 | F. S. K. OSCILLATOR |
| 705 | OUTPUT AMPLIFIER |
| 706 | REGULATOR |
| 707 | MASTER OSCILLATOR I |
| 708 | MASTER OSCILLATOR II |

g. MED SPECIFICATIONS. Table 5 lists MED technical characteristics.

Table 5. MED TECHNICAL CHARACTERISTICS

| <u>Item</u> | <u>Description</u> |
|-----------------------|------------------------|
| OUTPUT MESSAGE: | |
| Number of Characters | Up to 24 |
| Code | 8-bit Fielddata |
| Speed | 75 baud |
| Parity | Odd |
| DATA FREQUENCIES: | |
| Logic 1 | 1317.5 cps |
| Logic 0 | 1232.5 cps |
| OUTPUT LEVEL | 0dbm, -5dbm, or -10dbm |
| OUTPUT IMPEDANCE | |
| Line | 600 ohms |
| Radio | 150 ohms |
| OPERATING ENVIRONMENT | -25°F to +125°F |

Table 5. MED TECHNICAL CHARACTERISTICS (Cont'd)

| <u>Item</u> | <u>Description</u> |
|----------------------------|--------------------------------------|
| MAXIMUM OPERATING ALTITUDE | 10,000 feet |
| ACTIVE COMPONENTS | 104 transistors |
| POWER REQUIREMENTS | 6-volt and 1.5-volt battery supplied |
| DIMENSIONS | |
| Height | 5-1/2 inches |
| Width | 12 inches |
| Depth | 8-3/8 inches |
| WEIGHT | 13 pounds |

h. TESTS. Before shipment, both MEDS were subjected to a preliminary acceptance test program at STELMA. The acceptance tests included four phases: (1) Visual and Mechanical Inspection, (2) Electrical Tests, (3) Performance Tests, and (4) Environmental Tests.

(1) The Visual and Mechanical Inspection checked on such items as soldering, finish, ease of operation of controls, and mechanical fit.

(2) The electrical tests included a check of panel lights, output level, output frequencies, and output bit rate.

(3) The performance tests required the use of an AN/TYC-1 (XC-3) Data Receiver to check message accuracy under extremes of temperature. Also included in the performance tests were 50- and 100-hour operating life tests.

(4) The environmental tests on the MED conducted at STELMA included temperature tests and a watertightness test.

Both MEDS passed all tests performed.

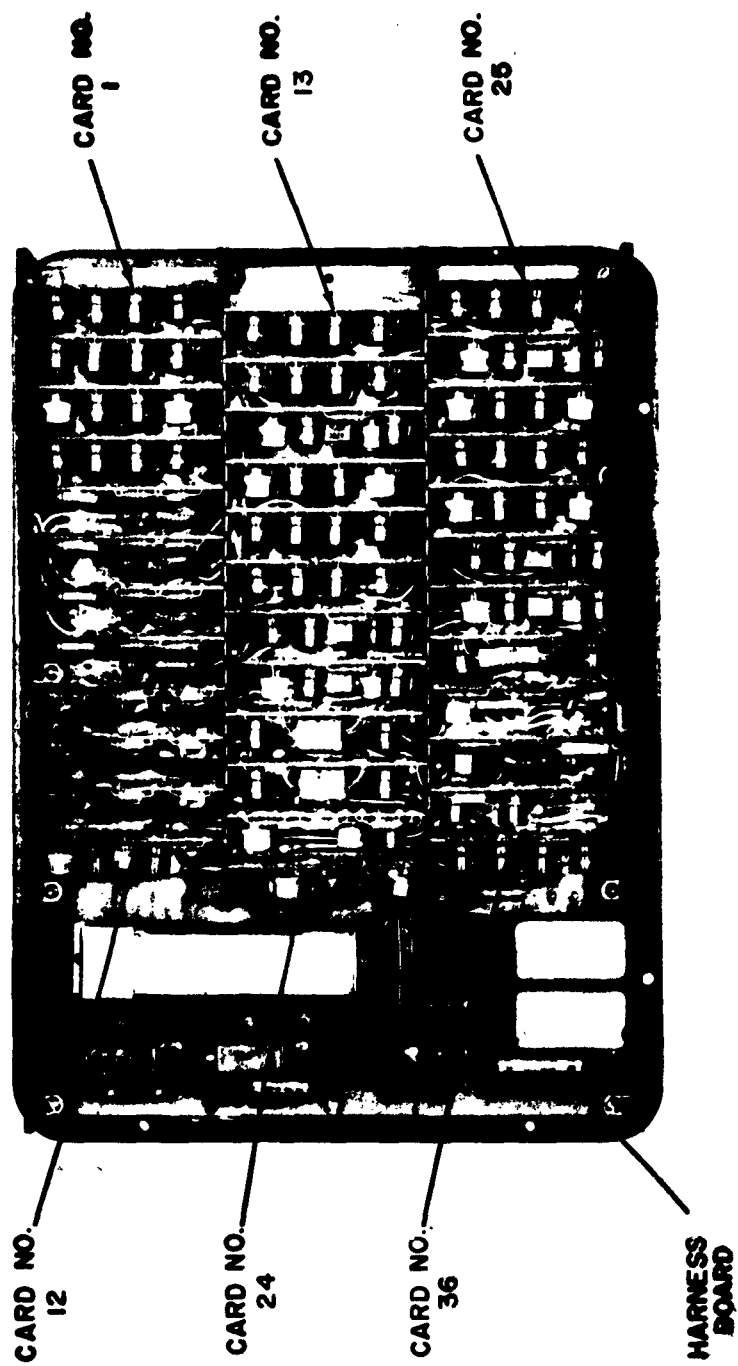


FIGURE 8
MESSAGE ENTRY DEVICE SSIA, IDENTIFICATION OF ASSEMBLIES

5. Over-all Conclusions

The following conclusions are derived from results obtained during the contract period.

a. Circuitry capable of satisfactory operation under severe environmental conditions was designed to operate using battery power.

b. Using state-of-the-art packaging techniques, complex electronic equipment has been made compact enough for easy hand carrying.

c. Problems arising during the development period have been overcome.

d. Message Entry Device SS1A meets or exceeds the requirements of the equipment specification.

6. Recommendations

While the present design satisfies equipment specification, there are some areas where further consideration may be of value. These are discussed in the paragraphs below.

a. The design of the Message Entry switch might be changed to facilitate quantity manufacture. This would lower the cost of the switch as well as make the operating characteristics more nearly identical.

b. A change in the design of the heading strips would allow easier changes in MED format.

c. A higher bit rate could be adopted. Most of the present MED electronics is able to operate at bit rate of 1200 bits per second and higher. Using a 1200-bps rate, the 24-character message would require only 0.16 seconds for transmission rather than 2.56 seconds in the present equipment. Transmitting the message in a shorter burst would enhance the safety of the forward observer. A time-division multiplex of voice-plus-data technical can be used, if voice-plus-data is retained. A voice dropout of 0.16 seconds when data was being transmitted would hardly be noticeable to a hearer.

7. Identification of Key Personnel

A total of 6350-3/4 engineering hours was incurred on the project during the period covered by this report. Of this engineering time, 5122 hours were distributed among Key STELMA personnel as specified in the following table.

| <u>Name</u> | <u>Title</u> | <u>Hours</u> |
|-------------------|----------------------------|--------------|
| Dr. N. Kramer | Project Manager | 78-1/2 |
| Mr. B. Krauss | Project Engineer | 525-3/4 |
| Mr. H. Robbins | Associate Project Engineer | 1041-1/4 |
| Mr. S. Schneider | Mechanical Designer | 1453-3/4 |
| Mr. W. Kaszics | Design Engineer | 1982-3/4 |
| Mr. R. Ashenbrand | Technician | 40 |

APPENDIX A

MESSAGE ENTRY SWITCH POSITIONS FOR FIELD ARTILLERY

| <u>Input Function</u> | <u>Mode</u> | <u>Row</u> | <u>Switch</u> | <u>Remarks</u> |
|-----------------------|-------------|------------|---------------|--|
| Observer Identity | Top | 1 | 1 | Identity of observer (from 0 to 9). |
| Type target | Top | 1 | 2 | Describes nature of target: 0 - Infantry in open 1 - OP in open 2 - Infantry dug in 3 - Command post 4 - Infantry weapons 5 - OP dug in 6 - Mortars 7 - Artillery 8 - Armor 9 - Supply dumps |
| Scale/Density | Top | 1 | 3 | Describes size and relative target density: 0 - Scale 1/Density 1 1 - Scale 1/Density 2 2 - Scale 2/Density 1 3 - Scale 2/Density 2 4 - Scale 3/Density 1 5 - Scale 3/Density 2 6 - Scale 1/Density 2 Battalion 8 - Scale 3/Density 2 All available |
| Method/type fire | Top | 1 | 4 | Method and type of fire requested: 0 - Volley 1 - Salvo Right |

MESSAGE ENTRY SWITCH POSITIONS FOR FIELD ARTILLERY (Cont'd)

| <u>Input Function</u> | <u>Mode</u> | <u>Row</u> | <u>Switch</u> | <u>Remarks</u> |
|-----------------------|-------------|------------|---------------|---|
| | | | | 2 - Salvo Left 3 - Registration 4 - High Angle Volley 5 - High Angle Salvo Right 6 - High Angle Salvo Left 7 - Destruction 8 - Bracket |
| Azimuth | Top | 1 | 5, 6, 7 | Observer-Target to nearest 10 mils, 0 to 6400. |
| Known point | Top | 2 | 1, 2, 3 | Observer's identification of a known point in impact area. |
| | | | | 0 to 999 available for concentrations and registration points. |
| Deviation | Top | 2 | 4 | Gives direction of shift for initial fire request, subsequent fire request, or sensings for precision fire: R - right L - left Ln - line |
| | | | 5, 6, 7 | Amount of deviation correction in tens of meters. |
| Altitude change | Top | 3 | 1 | Gives direction of shift for altitude or height of burst, and sensings for precision fire: U - up D - down U1 - up 100 D1 - down 100 A - air |

MESSAGE ENTRY SWITCH POSITIONS FOR FIELD ARTILLERY (Cont'd)

| <u>Input Function</u> | <u>Mode</u> | <u>Row</u> | <u>Switch</u> | <u>Remarks</u> |
|-----------------------|-------------|------------|---------------|---|
| Range | Top | 3 | | G - graze HA - height air LA - low air D - dud |
| | | | 2 | Gives amount of correction in tens of meters. |
| | | | 3 | Gives direction for range correction for initial fire request, subsequent fire request, and sensings for precision fire: 0 = add - = drop +50 = add 50 -50 = drop 50 ? = doubtful T = target L = lost RR = repeat range D = distance |
| Fuze/sheet | Top | 3 | 4, 5 | Gives amount of range correction in hundreds of meters. |
| | | | 6 | Gives observer shell/fuze option: HE/Q - high explosive fuze quick HE/T - high explosive fuze time HE/VT - high explosive fuze VT HE/D - high explosive fuze delay |

MESSAGE ENTRY SWITCH POSITIONS FOR FIELD ARTILLERY (Cont'd)

| <u>Input Function</u> | <u>Mode</u> | <u>Row</u> | <u>Switch</u> | <u>Remarks</u> |
|-----------------------|-------------|------------|---------------|---|
| Control | Top | 3 | 7 | <p>WP - white phosphorous</p> <p>HE/WP - high explosive quick and white Phosphorous</p> <p>CP - high explosive fuze concrete piercing</p> <p>ILL - illumination</p> <p>SMK - smoke</p> <p>Gives observer type control he desires:</p> <p>WA - will adjust</p> <p>WA/AC - will adjust at my command</p> <p>FE - fire for effect</p> <p>FE/AC - fire for effect at my command</p> <p>FWR - fire when ready</p> <p>RF/C - repeat fire for effect at my command</p> <p>CF - cease fire</p> <p>F - fire</p> <p>EM - end of mission</p> <p>EMR - end of mission re-plot</p> |
| Observer identity | Bottom | 1 | 1 | Same as mode top, row 1, switch 1. |
| Effect of fire | Bottom | 1 | 2 | <p>Gives result of fire for effect, and what happened to target:</p> <p>0 - neutralized</p> <p>1 - burning</p> |

MESSAGE ENTRY SWITCH POSITIONS FOR FIELD ARTILLERY (Cont'd)

| <u>Input Function</u> | <u>Mode</u> | <u>Row</u> | <u>Switch</u> | <u>Remarks</u> |
|-----------------------|-------------|------------|---------------|--|
| | | | | 2 - neutralized and burning 3 - dispersed 4 - destroyed 5 - destroyed and burning |
| Number killed | Bottom | 1 | 3 | Gives number of personnel killed in tens. |
| Number Wounded | Bottom | 1 | 4 | Gives number wounded personnel in tens. |
| Azimuth of withdrawn | Bottom | 1 | 5, 6, 7 | Same as azimuth in mode top, row 1, switches 5, 6, 7. |
| Easting coordinates | Bottom | 2 | 1, 2, 3, 4 | Gives easting coordinates of target to nearest 10 meters. |
| Altitude | Bottom | 2 | 5, 6, 7 | Gives altitude of target to nearest 5 meters or nearest 10 feet. |
| Northing coordinates | Bottom | 3 | 1, 2, 3, 4 | Gives northing coordinates of target nearest 10 meters. |
| Shell/fuze | Bottom | 3 | 6 | Same as mode top, row 3, switch 6. |
| Control | Bottom | 3 | 7 | Same as mode top, row 3, switch 7 |

APPENDIX B
DIGITAL DATA TERMINAL
AN/TYC-1 (XC-3)

Final Report
by
STELMA, Inc.

Report No. 4

Contract No. 804 342

Final Report

25 October 1960 to 30 November 1961

**DEVELOPMENT OF
DIGITAL DATA TERMINAL AN/TYC-1(XC-3)**

Philco Specification 98-3351

Signal Corps Technical Requirement SCL-1940

OBJECT:

**The development of a rugged, reliable
field-transportable digital-data transmitter
and receiver.**

**Report Prepared by:
A. Brooks**

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| A | Serial Operation of the AN/TYC-1 |
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1. Purpose

The primary purpose of this project is to develop and construct a rugged, highly reliable, field-transportable digital-data receiver and transmitter. These equipments are to be used for transfer of data-processing information over military voice-communication channels and commercial voice channels. Specifications covering this equipment are listed in Signal Corps Technical Requirement SCL-1940 and Philco Specification 98-3351 dated 25 August 1960, Revision A dated 15 September 1960.

The transmitter accepts eight parallel inputs at one of three switch-selected character rates: 150, 75, or 9.375 characters per second. The transmitter converts the parallel inputs to a serial string of data (at 1200, 600 or 75 bits per second, respectively), from which it derives a frequency-shifted data signal that is applied to the voice-frequency channel.

At the receiver, the frequency-shifted signal is demodulated to the serial string of data, which is then converted to parallel data. Outputs available from the receiver include eight parallel data-output lines, one serial data-output line, and bit and character timing pulses.

2. Abstract

a. Engineering development of Digital Data Terminal AN/TYC-1 (XC-3) was initiated on 25 October 1960. Designed to be a Fielddata-system compatible data terminal, similar to the AN/TYC-1(XC-2), the unit was also to be capable of narrow-band, low data-rate, data transmission for voice-plus-data application.

b. Acceptance testing of the first two units was performed on 13 to 15 September 1961, and the units were delivered on 15 September 1961.

c. Acceptance testing of the remaining units was performed on 2 to 6, and 10 to 12 October 1961. These units were delivered on 18 October 1961.

d. Digital Data Terminal AN/TYC-1(XC-3) fulfills the object of the contract and meets or exceeds the requirements of the equipment specification.

3. Reference Material

a. PUBLICATIONS. For information on the Digital Data Terminal AN/TYC-1, refer to the following:

- (1) STELMA Technical Proposal for Digital Data Terminal AN/TYC-1 Modified for Operating at Speeds of 1200, 600, and 75 Bits Per Second, 7 September 1960.**
- (2) Philco Specification for AN/TYC-1 Transmitter and Receiver Units SS1A, Number 9S-3351, 25 August 1960, and Revision A, 15 September 1960.**
- (3) Signal Corps Specification SCL-1940C, 15 July 1960.**
- (4) Instruction Manual for Digital Data Terminal AN/TYC-1, Engineering Test Model.**
- (5) Fielddata Equipment Intercommunication Characteristics, 1 April 1959, Revised 1 August 1959.**
- (6) Final Design Plan for Digital Data Terminal AN/TYC-1(MOD), January 1961.**
- (7) Test Program for Digital Data Terminal AN/TYC-1(MOD) 21 March 1961.**
- (8) Report No. 1, First Quarterly Progress Report, 25 October 1960 to 31 December 1961, Messrs. A. Brooks and B. Krauss, STELMA, Incorporated.**
- (9) Report No. 2, Second Quarterly Progress Report, 1 January 1961 to 31 March 1961, Mr. A. Brooks, STELMA, Incorporated.**
- (10) Report No. 3, Third Quarterly Progress Report 1 April 1961 to 30 June 1961, Messrs. A. Brooks and R. Mottino, STELMA, Incorporated.**
- (11) Technical Manual for Digital Data Terminal AN/TYC-1(XC-3), CTM-4012, August 1961, STELMA, Incorporated.**

b. CONFERENCES. During the contract period, the following eight conferences were held.

(1) A conference at Philco Corporation, Willow Grove, Pennsylvania, on 30 November 1960, was attended by:

STELMA

Philco

Dr. N. Kramer
Mr. B. Krauss
Mr. S. Schneider

Mr. F. Laverghetta
Mr. H. Schwartz
Mr. H. Glazer
Mr. F. Spera

The design plan phase of the AN/TYC-1 (MOD) was discussed, and test procedures for evaluating electrical performance were considered.

The question of nomenclature for the modified AN/TYC-1 was raised. This was later resolved by U.S.A.S.R.D.L, and the nomenclature "AN/TYC-1(XC-3)" was adopted.

(2) A conference at STELMA, Incorporated, on 10 February 1961, was attended by:

STELMA

U.S.A.S.R.D.L.

Philco

Dr. N. Kramer
Mr. B. Krauss
Mr. A. Brooks

Mr. J. Cox
Mr. A. DeRosa

Mr. H. Schwartz
Mr. H. Glazer

The AN/TYC-1(XC-3) design plan was discussed, and the visitors were shown the breadboard unit and some printed-circuit assemblies used in the AN/TYC-1.

(3) A conference at STELMA, Incorporated, on 25 April 1961, was attended by:

STELMA

U.S.A.S.R.D.L.

Philco

Dr. N. Kramer
Mr. B. Krauss
Mr. H. Robbins
Mr. A. Brooks
Mr. S. Schneider

Mr. J. Cox

Mr. H. Glazer
Mr. F. Spera

The following points were discussed:

(a) The new sync character and order of transmission of serial bits.

(b) Use of the TYC-1 in a rack-mounted installation.

The possibility of thermal problems due to restricted vertical air flow was pointed up. Philco was assured that RF pickup would not be a problem in the TYC-1.

At the meeting, Philco proposed some additional reliability tests to be incorporated into the test program.

(4) A conference at STELMA, Incorporated, on 20 June 1961, was attended by:

| <u>STELMA</u> | <u>Philco</u> |
|----------------|--------------------|
| Mr. R. Plouffe | Mr. H. Glazer |
| Dr. N. Kramer | Mr. W. Livingstone |
| Mr. A. Brooks | |

At the conference, a revised delivery schedule for the TYC-1's was discussed. Agreement was reached on the nature of tests to be added to the test program.

(5) A conference at STELMA, Incorporated, on 27 June 1961, was attended by:

| <u>STELMA</u> | <u>U.S.A.E.P.G.</u> | <u>U.S.A.S.R.D.L.</u> | <u>Philco</u> |
|----------------|---------------------|-----------------------|---------------|
| Dr. N. Kramer | Capt. Enslow | Mr. J. Stout | Mr. H. Glazer |
| Mr. A. Brooks | | Mr. J. Cox | Mr. V. Sontag |
| Mr. H. Robbins | | | |

Synchronization and data-detection techniques were discussed.

(6) A conference at Philco Corporation, Willow Grove, Pennsylvania, on 22 August 1961, was attended by:

| <u>STELMA</u> | <u>Philco</u> |
|----------------|---------------|
| Mr. B. Krauss | Mr. H. Glazer |
| Mr. H. Robbins | |

A prototype Data Terminal AN/TYC-1 was delivered to permit Philco to perform system studies while awaiting delivery of AN/TYC-1(XC-3) units. The equipment was set up and operated in conjunction with a test fixture. Operation of the TYC-1 was discussed.

(7) Conferences at STELMA, Incorporated, on 13 to 15 September 1961, were attended by:

STELMA

Philco

Dr. N. Kramer
Mr. A. Brooks

Mr. S. Caldwell
Mr. J. Zimmerman

Acceptance testing of AN/TYC-1(XC-3), serial numbers 1 and 2, was performed. In addition to operational and environmental tests, and a 50-hour continuous run, one of the units (serial number 1) was subjected to drop and bench-handling tests. At the conclusion of the test series, the units were again operated. Mr. Zimmerman found the test results acceptable.

(8) Conferences at STELMA, Incorporated, on 2 to 6, and 10 to 12 October, 1961, were attended by:

STELMA

Philco

Dr. N. Kramer
Mr. B. Krauss
Mr. A. Brooks

Mr. S. Caldwell
Mr. J. Zimmerman

Acceptance testing of AN/TYC-1(XC-3), serial numbers 3 and 4, was performed. The signal detector circuit was modified to improve performance at the low speed. The units were put through operational and environmental tests and a 50-hour continuous run. In addition, a quality control inspection was performed. Test results were found acceptable.

4. Factual Data

a. GENERAL. Digital Data Terminal AN/TYC-1(XC-3) consists of a transmitter module and a receiver module that operate as synchronized digital repeaters.

(1) The transmitter accepts 8-parallel-bit characters, occurring at a rate of 150, 75, or 9.375 characters per second (switch selectable). The transmitter's single output is a serial string of frequency-shifted audio tones, representing the data inputs, transmitted at 1200, 600, or 75 bits per second, respectively.

(2) The receiver detects the frequency-shift tones received at a remote point via a voice-frequency channel, and reproduces 8-parallel-bit characters at a rate of 150, 75, or 9.375 characters per second (switch selectable). A serial output which reproduces the detected data at the rates of 1200, 600, or 75 bits per second is also available from the receiver.

b. BACKGROUND

(1) STELMA, Incorporated, has been engaged in the development of an FSK data terminal compatible with Fielddata system requirements (under Signal Corps contract) since 30 June 1958. Two different models of Digital Data Terminal AN/TYC-1 were developed.

(a) The AN/TYC-1(XC-1), first Engineering Test Model, as delivered to U.S.A.S.R.D.L, uses 900 and 2100 cps as the two audio tones of the FSK signal. Information is transferred at the rate of 1200 bits per second. Subsequent to the delivery of the XC-1 model, SCL-1940 was revised. This specification change was reflected in the second model delivered, designated XC-2.

(b) The AN/TYC-1(XC-2), second Engineering Test Model, uses 1200 and 2400 cps as the two FSK-signal audio tones. Information is transferred at rates of 1200, 600, or 300 bits per second (switch selectable).

(2) A Philco Corporation purchase order dated 22 September 1960 was received on 25 October 1960, and data terminal development was begun. The requirements for this terminal at first designated AN/TYC-1 (MOD) and later changed to AN/TYC-1(XC-3), are given in Philco Corporation Specification Number 9S-3351.

(3) Briefly, the AN/TYC-1(XC-3) includes data rates of 1200, 600, and 75 bits per second (switch selectable). The two higher rates use the same FSK frequencies and modulation-demodulation techniques as the XC-2 model. Information is transferred at the lower rate as a narrow-band FSK signal, suitable for voice-plus-data applications. Standard narrow-band FSK modulation-demodulation techniques are used.

(4) STELMA'S "building-block" approach to data terminal design resulted in an XC-3 design and fabrication program, with relatively few difficulties. Early in data terminal development "universal" digital circuitry (e.g., flip-flop, shift register, converter, blocking oscillator, etc.) was designed. These circuits were then laid out on standard, interchangeable, printed-circuit assemblies. The standard assemblies were utilized, as far as practicable, in design of the XC-3 model of the TYC-1.

(5) The special circuits needed for the narrow-band FSK modulation and demodulation were adapted from circuits used in the STELMA-designed Telegraph-Telephone Terminal AN/TCC-29.

(6) Delivery of Digital Data Terminal AN/TYC-1(XC-3), serial numbers 1 and 2 was accomplished on 15 September 1961, and of units, serial numbers 3 and 4, on 18 October 1961.

c. SYSTEM DESIGN DATA.

(1) Strobe-Ready Relations. The basic Fieldata strobe-ready philosophy is defined on pages 45 through 47 of the Fieldata Equipment Intercommunication Characteristics (orange book). Digital Data Terminal AN/TYC-1 was designed for Fieldata-system compatibility. A system block diagram is shown in figure 1.

(a) In the stand-by condition, a "ready" level (nominal-3 volts) from the transmitter is applied to the data source. When data is available, the source generates a strobe pulse to initiate transmitter operation. Upon receipt of the strobe pulse, transmission begins and the ready-level output is removed (i.e., becomes 0 volts). When the transmitter is ready for the next character of the transmission, the ready level is reapplied. Each new character from the source is accompanied by a strobe pulse; the transmitter removes the ready level as each new data character is presented, and reapplies the ready level when the data is sampled and stored.

(b) Each new character out of the receiver is accompanied by a strobe pulse, which provides timing for the data sink.

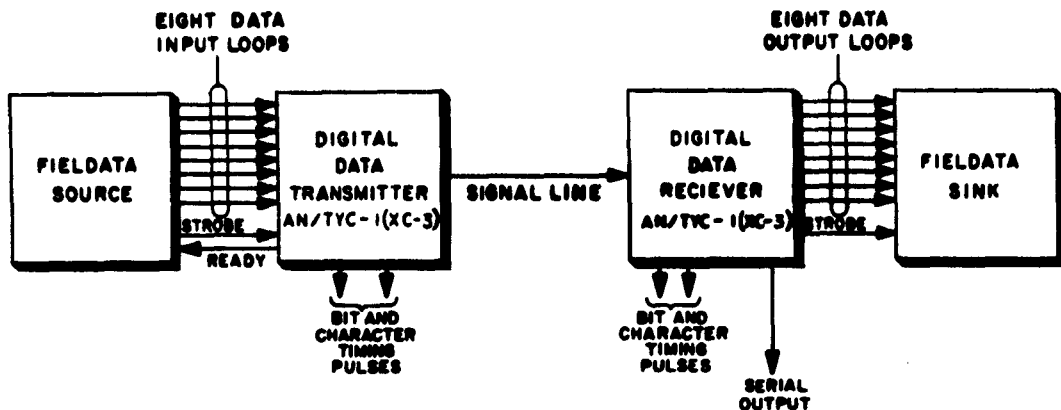


Figure 1 Digital Data Terminal AN/TYC-1 (XC-3)
system block diagram

(2) Synchronization. Synchronization of the receiver to the transmitter is accomplished by a special synchronizing (sync) character, which is generated by the transmitter and transmitted as the first two characters of any transmission. The sync character is used by the receiver but does not appear at the receiver's data outputs. Between transmissions, the last data character of the previous transmission is retained by the parallel outputs. The parallel outputs change only when a new data character is available. At the serial output, a steady data-0 level is produced between transmissions.

(a) In the AN/TYC-1(XC-3), the synchronizing character used is 01001111, where the rightmost is the least-significant digit, and the first bit transmitted. * This sync character is similar to patterns adopted by other users of data terminals.

(b) At the 1200- and 600-bps rates, the data 0 is a 1200-cps tone, and the data 1, a 2400-cps tone. The relationship between data-0 frequency, 1200-bit rate, and data-1 frequency is therefore 1:1:2. Data transitions occur at zero crossings only, and no sharp discontinuities appear in the transmitted signal.

(c) Since, at the 1200- and 600-bps rates, the data tones are related to, and are derived from the same clock as the bit rate, timing

* A convention that is followed throughout this report.

information for receiver bit synchronization is carried by the zero crossings of the transmitted signal. The receiver has certain built-in timing criteria by which it selects a particular zero crossing on which to effect bit synchronization (initial phasing of the bit-timing chain). The first 1200-cps zero crossing (appearing in the fifth bit of the sync character), is used.

(d) At the 75-bps rate, synchronization is effected on transitions of the detected data. Bit synchronization occurs on the first signal 1-to-0 transition. This appears at the end of the fourth bit of the sync character.

(e) After bit synchronization, detected data can be correctly sampled. The incoming data begins to load, serially, a 1-character register. When the register contains the second sync character, decoder gates connected to the register detect the character's presence and emit a character-sync (frame lock) pulse. This is used to phase the character-timing counter, and succeeding data characters will be properly oriented in the parallel output register.

(3) Additional Features. Some additional design features, providing greater flexibility in utilizing the TYC-1 in various systems, are described below.

(a) Ringing transmission lines can cause faulty synchronization if transmission is resumed immediately after having been discontinued. The transmitter contains an internal jumper, connecting the 1 CHAR OFF jacks. This provides a minimum delay (equal to one character interval) before transmission, once discontinued, can be resumed. Where the transmission line exhibits ringing characteristics, the jumper can be connected between the 2 CHAR OFF jacks. In this position, minimum delay equal to two character intervals is provided before the transmission can be resumed.

(b) External clock inputs are provided in both the transmitter and the receiver. An internal jumper may be connected so that the TYC-1 timing chains are driven by a signal from the external clock inputs.

(c) Bit-and character-timing pulse outputs are provided for possible use by other modules in the system. These timing outputs are available from both the transmitter and receiver.

(d) A serial-data output from the receiver is provided. It is electrically independent from the parallel output, and the two may be

used simultaneously. Considerations affecting serial operation of the data terminal are discussed in a Stelma memo (from Mr. Bert Krauss), dated 16 February 1961, and included as appendix A of this report.

d. LOGICAL DESIGN.

(1) General. A "building-block" approach was chosen early in the data terminal development program. Standardized flip-flop, shift register, logic gate (etc.) circuits were designed and packaged in accordance with this concept. As a result, a series of interchangeable, compact, printed-circuit, plug-in assemblies were developed. These were designed to provide maximum flexibility in the logical design and assembly of the digital data terminal.

(2) Diode logic (logic-1 level, +10 volts; logic-0 level, 0 volts) is used and designed for OR-AND configuration where two levels of logic are required.

(3) The following paragraphs describe transmitter and receiver logic.

e. TRANSMITTER LOGIC (figs. 2 and 3).

(1) Function.

(a) The transmitter samples eight parallel channels of dc information, from a data source, and converts these parallel data bits to a serial string of frequency-shift data suitable for transmission over voice-frequency channels. Because information at each of the eight inputs changes at the rate of 150, 75, or 9.375 bits per second, the required output rate for serial transmission is eight times greater (1200, 600, or 75 bits per second, respectively).

(b) A "ready" output indicates to the data source that the transmitter is ready for new data. Whenever new data is present, a strobe signal from the data source initiates operation of the transmitter logic. To restore the serial data, at the receiver, to groups of eight parallel bits, the transmitter frame-locks the receiver (provides character synchronization at 150, 75, or 9.375 pps) by generating a special 8-bit synchronizing character and transmitting it twice when first going on the air.

(c) Refer to figure 11 to establish transmitter key circuit timing relationships.

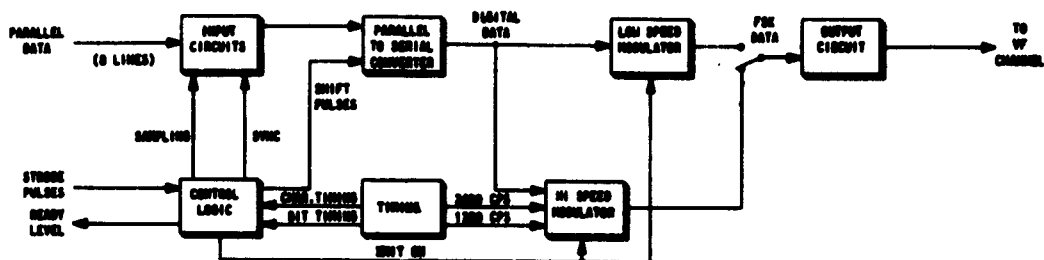


Figure 2 Transmitter, block diagram

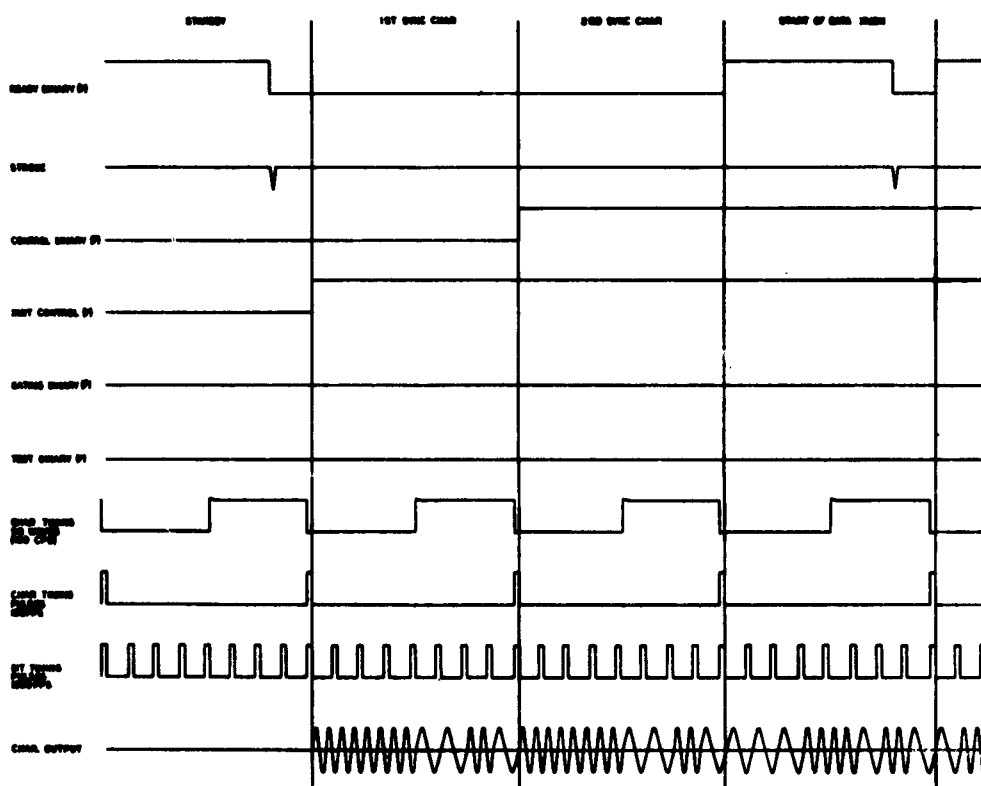


Figure 3 Transmitter, timing relationships

(2) **Timing Logic.** . All pulse rates used for transmitter timing are derived from a 2400-cycle tuning-fork oscillator. The 2400-cps frequency is divided down, by a binary chain, to the required bit and character rates for timing control-logic operation. The 2400-cps and 1200-cps square-wave outputs are used to produce 2400-cps and 1200-cps sinusoidal voltages for the frequency-shift signals the transmitter applies to the line.

(3) **Control Logic.** . Transmitter control logic determines how the unit is to operate, depending upon the setting of the MODE switch (OPERATE, TEST, or SYNC) as well as prevailing conditions.

(a) During normal data transmission (i. e., MODE switch set to OPERATE), control logic makes decisions according to information it stores. When the transmitter is ready for new input data, control logic applies a ready level to the Fielddata source. Any data available at the source is applied to transmitter input logic, and a strobe signal is applied to control logic, causing the ready level to be removed so that the source cannot change its data output. According to the state of control (standby, sync generation, data transmission, and "off", each of which represents a phase of the operational sequence), the circuit produces the appropriate outputs.

(1) **STANDBY.** The Xmit-on level is a 0, muting transmitter output, and the ready level is applied to the data source. Sync signal and shift pulses are being generated; therefore, sync characters are continually being shifted through the serial register. If a strobe (and data) are received, the ready level is removed and transmission will begin on the next transmitter character time.

(2) **SYNC GENERATION.** The character-rate pulse mentioned above makes the Xmit-on level a 1, allowing the generated sync character to be applied to the signal line. The ready level is held off while two sync characters are transmitted. The next character-rate pulse steps control logic to the data transmission phase. Data is sampled, and the ready level reapplied. The sync output is disabled, and the Xmit-on level maintained.

(3) **DATA TRANSMISSION.** The sampled data is transmitted. Each new strobe pulse (accompanied by a new data character) causes the ready level to be removed. Each subsequent character-rate pulse causes the new data to be sampled and the ready level to be reapplied. If no strobe is received for a full character interval, the next character-rate pulse causes the Xmit-on level to go to 0, muting transmitter output. Control logic is in the standby phase for a minimum

time of one character length.

(4) OFF. This option is provided to improve operation on ringing lines, as an aid for receiver synchronization with the transmitter. When strapped for the off feature, transmitter operation is similar to that of standby, except that the ready level is held from the data source and transmission is prevented for an extra character duration. Therefore, the minimum delay before resuming transmission is two character intervals.

(b) In the test mode of operation (i. e., MODE switch set to TEST), control-logic generates one sync signal at the time the MODE switch is set, but the shift pulses are inhibited. Consequently, the sync character remains in the shift register, and the first bit (data 1) is continuously transmitted in cycles of three character intervals on and one off. When the output is monitored with a headset, the bit-1 tone is heard as a high-pitched whistling sound with a superimposed low rasping sound produced by the on-off cycling. Depression of the TEST button applies a shift pulse to the shift register, so that the bit-2 tone is heard. Each subsequent depression of the TEST button causes the next sync-character bit to be heard. After the seventh shift, repeated operation of the pushbutton should produce only a 1200-cps tone since the register is clear and contains all data 0's. (To repeat the test, MODE switch must be set to OPERATE, and then to TEST.)

(c) In sync mode of operation (i. e., MODE switch set to SYNC), sync characters are generated by input logic, in response to sync signal from control logic, and transmitted as control logic supplies shift pulses to the shift register, and maintains Xmit-on signal for three character intervals out of every four.

(4) Input Logic. Parallel data from the eight input lines is fed to the input logic. When a sampling pulse is received from control logic, the eight information bits are simultaneously transferred into the shift register. If, instead, a sync signal is generated by control logic, sync-character information is transferred into the shift register.

(5) Shift Register. Parallel-to-serial conversion is performed in the shift register. The register is loaded in parallel. The first bit is immediately applied to the modulator and transmitted. The first shift pulse from control logic causes the second bit to be transmitted. Successive shift pulses cause the sequential transmission of the remaining bits stored in the shift register. Shift pulses are applied at the selected bit rate during normal operation; during

test operation, a shift pulse is generated each time the TEST push-button is manually depressed.

(6) Hi-Speed Modulator. The 2400-cps and 1200-cps square waves from the timing circuit are fed to tuned amplifier, producing 2400-cps and 1200-cps sinusoidal voltages for the frequency-shift output signal. The modulator gates these frequencies so that when the final shift register stage is set to the 1 state, a 1200-cps (data-0) signal is produced, and when set to the 0 state, a 2400-cps signal is produced. The frequency-shift signals are fed to the output circuit. When the Xmit-on signal from the control logic goes off, no signal is applied to the signal line.

(7) Low-Speed Modulator. The output of the low-speed modulator, controlled by the shift register output, is normally 1317.5 cps (with data-1 input). When the shift register output is data 0, the low-speed modulator output changes to 1232.5 cps.

(8) Output Circuit. The output circuit amplifies the frequency-shift signal (from hi-speed or low-speed modulator) before it is applied to the line. The circuit contains a variable attenuator, which permits front-panel control of transmitter output level (adjustable in 2 db steps from +5 to -15 dbm). Taps on the output transformer permit impedance matching to different lines (1200 ohms with c. t. at 300 ohms, and 600 ohms with c. t. at 150 ohms).

f. RECEIVER LOGIC (fig. 4 and 5)

(1) Function. The receiver detects serial frequency-shift data carried on the line, translating it into parallel Fielddata signals corresponding to the inputs at the transmitter (the receiver simultaneously provides the data in serial form). Whenever data is present at the output of the receiver, it is accompanied by a strobe pulse. At the beginning of each transmission, the receiver receives two sync characters (01001111) from the transmitter. The first sync character effects bit synchronization between transmitter and receiver; the second, character synchronization. Neither sync character is applied as a receiver output, but all subsequent data in the transmission is. (For timing relationships of key receiver circuits, refer to figure 5.)

(2) Input Logic. Input logic receives the frequency-shift signals from the line. After equalization, amplification, and limiting, the frequency-shift signals are fed to the data detectors for conversion to data in the form of pulses or absence of pulses.

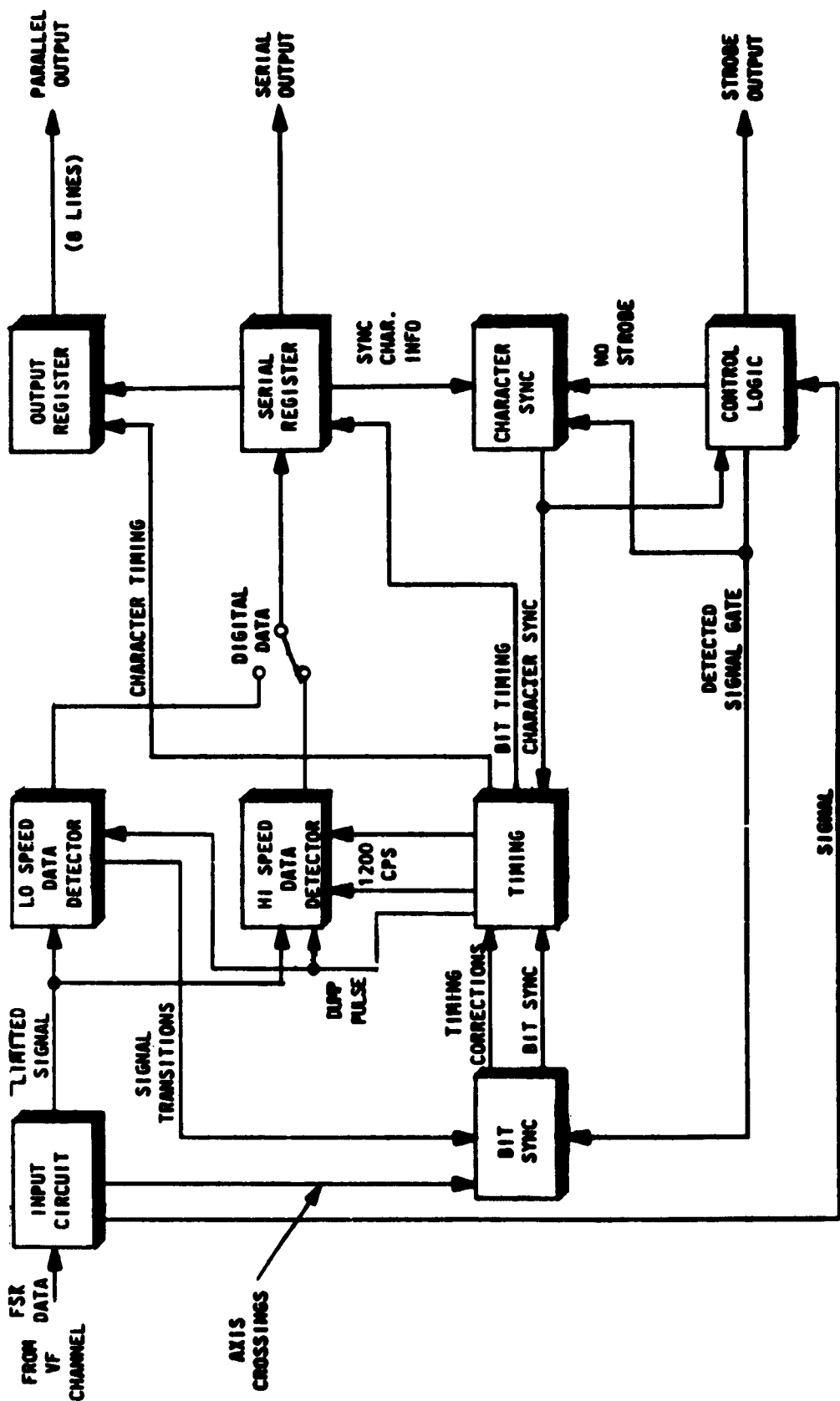


Figure 4 Receiver, block diagram

Input logic also produces pulses (both positive and negative) at each axis crossing of the high-speed input signal (an axis crossing is that point in time when the signal voltage goes through zero); the receiver uses axis crossings for synchronization. During low speed operation the output of the low-speed detector is used for synchronization.

(3) Data Detectors. In the data detector, the limited frequency-shift signals are translated into pulses for application to the serial register.

(4) Serial Shift Register. The serial data from the data detector is shifted into the serial register, at the selected bit rate (1200-, 600-, or 75-bps), by bit-rate pulses. At the end of each character, eight shift-register bistables transfer their contents, in parallel, to the output register. A separate serial output is available from the stage following the final shift-register stage.

(5) Output Logic. Data is transferred, in parallel, to the output register by character-rate pulses. The eight outputs (channels) are converted to Fieldata levels and applied to the eight parallel lines. The separate serial output is also converted to Fieldata levels, through an output converter, and is available from a separate pin in the output receptacle.

(6) Bit Sync Logic. Bit sync logic selects the initial 1200-cps axis crossing (during high-speed operation) or low-speed detector output transition (during low-speed operation), for initial phasing of all timing-chain bistables; subsequent 1200-cps axis crossings or low-speed detector data transitions are fed to the timing chain throughout transmission, to lock receiver timing to transmitter timing. Initial-bit synchronization is effected during reception of the first sync character. To prevent sync triggering by noise pulses when there is no signal transmission on the line, an inhibit gate is supplied to the bit sync circuit, from control logic.

(7) Character Sync Logic. Character sync logic contains gates which are enabled after the second sync character fills the serial register at the beginning of a transmission. A character-sync pulse is generated to actuate gates and reset the character-rate counter in the timing chain, thereby establishing character synchronization. All subsequent character-rate pulses are synchronized at the character rate of the incoming transmission. A sampling pulse and strobe can be produced only after the next character-rate pulse is generated

(which occurs one character time later than the character-sync pulse, at the instant the shift register contains the first data character). This delay in generating the first sampling pulse and strobe prevents the application of the two sync characters to the Receiver output.

(8) **Timing Logic IC.** The receiver's character and bit rates are derived from a highly stable 134.4-kc crystal oscillator. A bistable chain divides this frequency down to the required bit and the character rates. The character rate is obtained by applying the bit pulses to an additional scale-of-eight counter which divides the bit rate by eight. At the beginning of each transmission, bit-sync and character-sync pulses set the phases of the bistables in the timing chain. Timing corrections derived from the received signal are used to keep the receiver clock locked to the remote transmitter clock.

(9) **Control Logic IC.** In the operate mode, control logic monitors the input line to determine if a signal is being received. When an input signal is detected, control logic enables the synchronization circuits. Once receiver timing is synchronized to that of the transmitter, control logic permits the data outputs to change and generates strobe pulses. In the sync mode, a visual front-panel indicator indicates optimum data detection, used during system alignment. Test mode operation is similar to that of sync mode, except that a voltage reduction in the positive power supply serves as a marginal checking feature.

g. ELECTRICAL DESIGN.

(1) **General.** Digital Data Terminal AN/TYC-1 includes both digital and low-level audio circuitry. The latter is used for handling and processing the frequency-shifted signal appearing on the voice-channel. Design procedures involved the use of both theoretical worst-case analysis and extensive laboratory testing.

(2) **Semiconductor Data.** The following transistor types are used in the TYC-1: USN2N388, USN2N396A, USAF2N167A, USN2N333, USA2N328A, 2N595, 2N1038-2, and 2N1292.

(a) The USN2N388 (a general purpose, NPN, germanium-alloy transistor, designed primarily for rapid switching) is applied for the bulk of the digital logic circuitry and also in some low-level audio circuits.

(b) The USN2N396A (a PNP, germanium-alloy, switching

transistor) is used in applications similar to those of the USN2N308, wherever a PNP type is required.

(c) The USAF2N167A (a high-frequency, NPN, germanium switching transistor) found application due to its lower leakage and higher voltage breakdown characteristics.

(d) The USN2N333 (a grown-junction NPN, silicon, general purpose transistor), finds application as a high-impedance current source, and as an audio amplifier.

(e) The USA2N328A (a silicon fused-alloy, PNP, general purpose transistor) is used as a high-impedance current source.

(f) The 2N595 (an NPN, germanium, bilateral transistor) is used as a bipolar switch.

(g) The 2N1038-2 is a PNP, germanium, power transistor. In all TYC-1 power-supply applications, the collector dissipation remains well below the temperature-derated, 5-watt capability of this transistor.

(h) The 2N1292 (an NPN, germanium, power transistor) has 10-watt, temperature-derated capability.

(3) Additional Considerations. In the TYC-1(XC-3), many features (including switch-selectable speed, timing inputs and outputs, etc.) were incorporated. These necessitated the addition of front-panel controls, and a good deal more wiring to the front panel. During the prototype-fabrication phase, it was discovered that high-frequency signal components, from switching-circuits leads, were being picked up in low-level audio leads, enough so that operation was affected. Effort was expended in locating the noise sources and the points at which pick-up occurred. Key leads were shielded, reducing the noise level well below tolerable limits.

h. MECHANICAL DESIGN (fig. 6).

(1) The Digital Data Terminal comprises a transmitter (fig. 7) and a receiver (fig. 8), each mounted in a separate case that serves as a rainproof container for shipment, storage, and field use of the equipment. The cases are identical; each unit is provided with a handle that facilitates removal from the case.

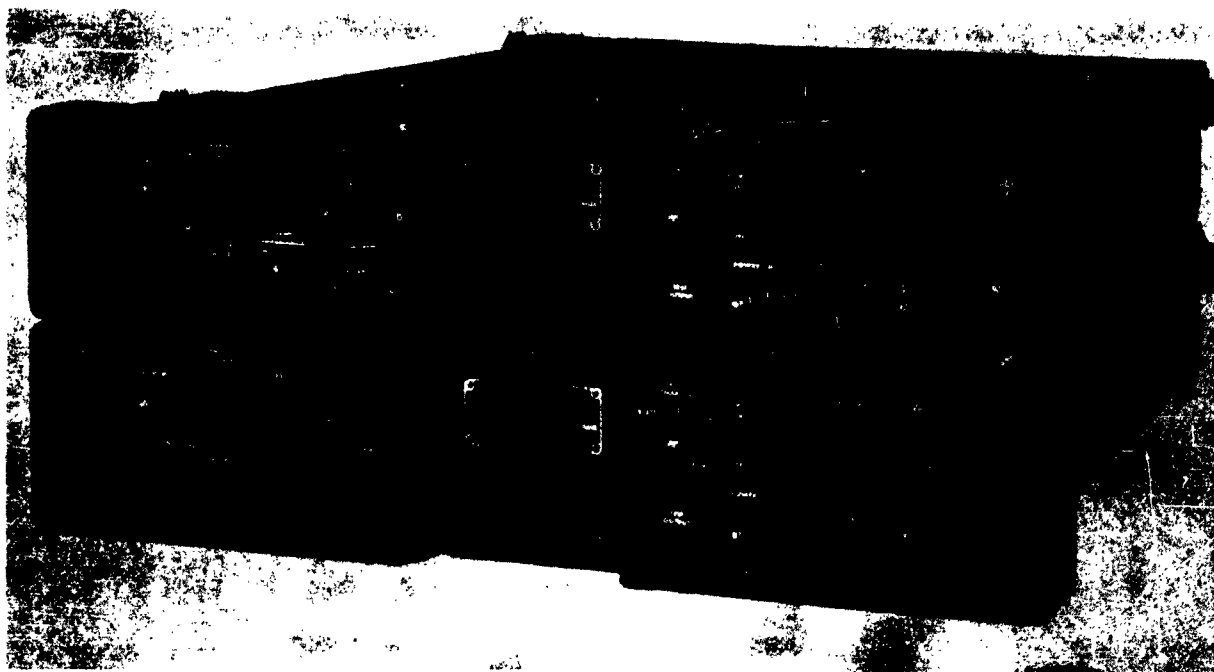


Figure 6 Digital Data Terminal AN/TYC-1 (XC-3)

(2) Key-pads at the top and bottom of each case permit the units to be stacked while in use; when stacked, the units may be securely locked together by latches provided at the sides of the transit cases. The Digital Data Terminal may also be mounted, without the transit cases, in any standard 19-inch rack or cabinet.

(3) Digital Data Terminal construction is modular; semi-conductor devices are used throughout. Each unit contains an integral power supply.

(4) Most circuitry is contained in plug-in, printed-circuit cards (Table 1), of which those of the same type are interchangeable. Card guides, running the depth of the chassis divide it into three sections (bays), so that each unit contains three rows of plug-in cards. These cards connect to two printed-circuit harness cards which plug into connectors located in the chassis frame, an arrangement that facilitates unit assembly and disassembly. Extractor handles are included for easy removal of each plug-in card. Tabs on the handles provide a convenient display of the nomenclature of each card.

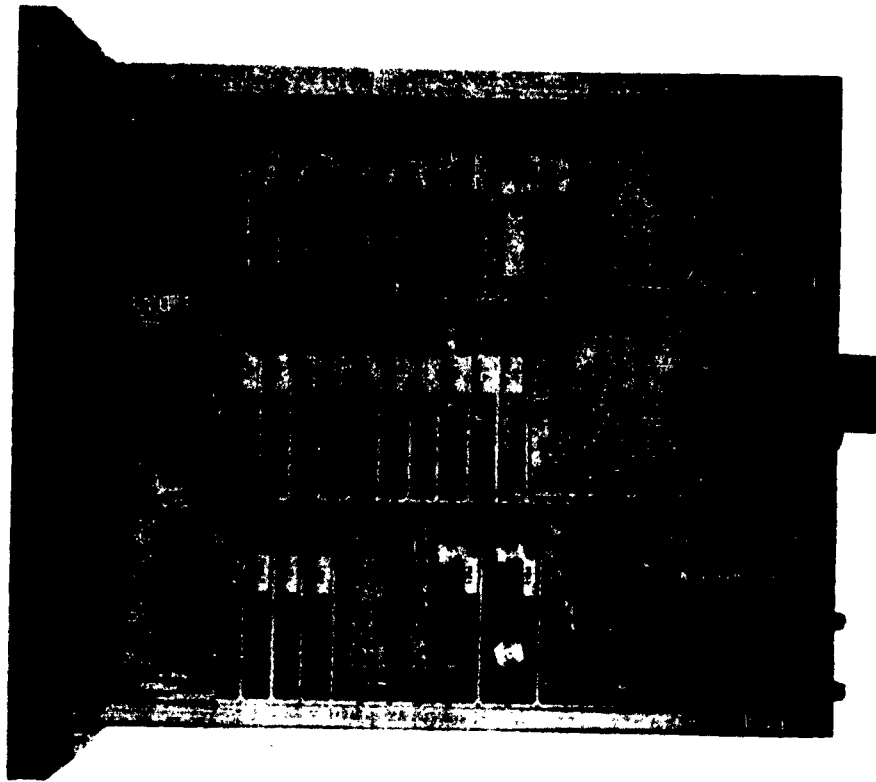


Figure 7 Transmitter, top view

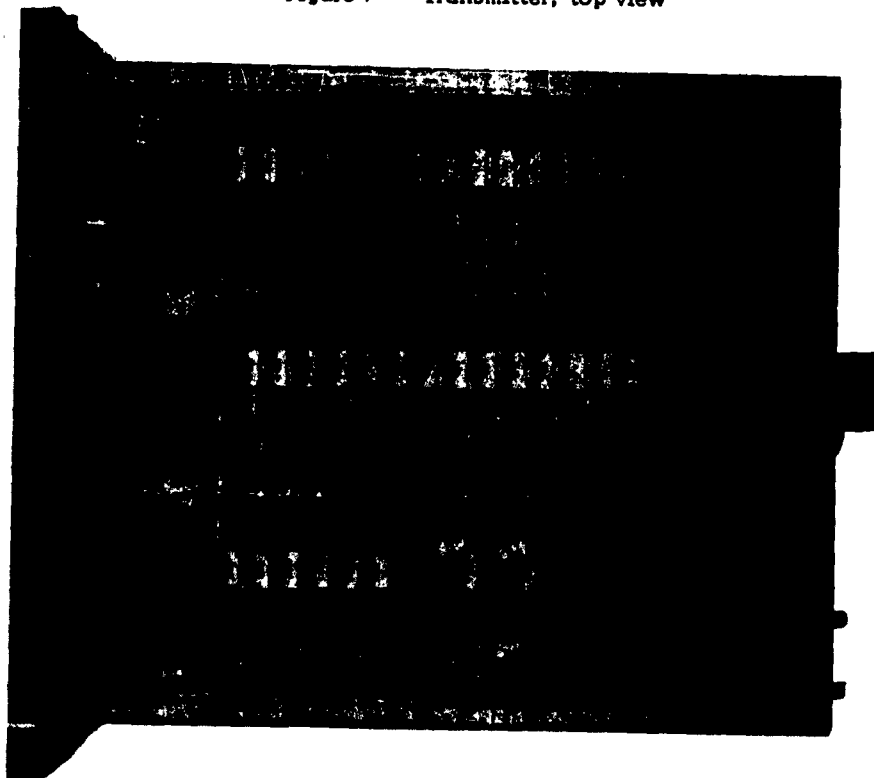


Figure 8 Receiver, top view

Table 1. DIGITAL DATA TERMINAL PRINTED-CIRCUIT PLUG-IN CARDS

| <u>Name</u> | <u>Nomenclature</u> | <u>Name</u> | <u>Nomenclature</u> |
|-------------------------------|---------------------|------------------------------|---------------------|
| Flip-Flop | F-2 | Signal Detector | SD2-2 |
| Shift Register | SR-2 | Delay Equalizer | DE-1 |
| Logic Gates | L-2 | Limiter | LIM-2 |
| Blocking Oscillator | BO-2 | Data Detector, High Speed | DD1-1 |
| Output Converter | OC-2 | Data Detector, Low Speed | DD2-1 |
| Unity Amplifier | UA-1 | Tuning Fork Oscillator | FO1-1 |
| Master Oscillator | MO-2 | Tuning Fork Amplifier | FO2-1 |
| Output Amplifier | OA-2 | Frequency Selector | FS-1 |
| Input Converter | IC-2 | Negative Power Supply | PS1-1 |
| Frequency-Shift Oscillator | FSO-1 | Positive Power Supply | PS2-1 |
| Modulator | MOD-2 | Tuned Amplifier | TA-1 |
| Signal Detector | SD1-2 | | |

(5) Design of the transmitter and receiver front-panel layouts is influenced by human-engineering consideration. Receiver controls and displays that are identical or analogous to those on the transmitter are placed in the same front-panel position on each unit.

(6) Duplicate sets of terminals are located on the front and rear panels of each unit. For field use, in stacked transit cases, all connections can be made to the front panel; in a rack-mounted installation, external connections may be made to either the front or the rear panel.

1. ENGINEERING TEST MODEL XC-3, CHARACTERISTICS

Technical data for the unit is given in Table 2.

Table 2. TECHNICAL CHARACTERISTICS

| <u>Item</u> | <u>Description</u> | | | | | | | | | |
|-----------------------|---|-----------------|------------------|-----------------|------------|----------|----------|-------|------------|------------|
| TRANSMITTER: | | | | | | | | | | |
| Data Input | 8 parallel bits. | | | | | | | | | |
| Levels | 0 and -3 volts into 150 ohms. | | | | | | | | | |
| Logic | -3 volts; data <u>one</u> . 0 volts; data <u>zero</u> . | | | | | | | | | |
| Input Bit Rate | 150, 75, or 9.375 bps per line. | | | | | | | | | |
| Total Bit Rate | 8 x 150 = 1200 bps. 8 x 75 = 600. 8 x 9.375 = 75. | | | | | | | | | |
| Type of Modulation | Frequency-shift. | | | | | | | | | |
| Data Output | Serial bits: <table><tr><th>Character Rate</th><th>Data <u>Zero</u></th><th>Data <u>One</u></th></tr><tr><td>150 and 75</td><td>1200 cps</td><td>2400 cps</td></tr><tr><td>9.375</td><td>1232.5 cps</td><td>1317.5 cps</td></tr></table> | Character Rate | Data <u>Zero</u> | Data <u>One</u> | 150 and 75 | 1200 cps | 2400 cps | 9.375 | 1232.5 cps | 1317.5 cps |
| Character Rate | Data <u>Zero</u> | Data <u>One</u> | | | | | | | | |
| 150 and 75 | 1200 cps | 2400 cps | | | | | | | | |
| 9.375 | 1232.5 cps | 1317.5 cps | | | | | | | | |
| Output Bit Rate | 1200, 600, or 75 bps. | | | | | | | | | |
| Output Levels | +5 dbm to -15 dbm (adjustable in 2 db steps). | | | | | | | | | |
| Output Impedance | 1200 ohms with c. t. at 300 ohms; 600 ohms with c. t. at 150 ohms. | | | | | | | | | |
| Communication Channel | Voice-frequency (VF). | | | | | | | | | |
| Strobe Input | Strobe pulse (-3 volts into 150 ohms) from data source primes transmitter for new data at input; absence of strobe pulses mutes transmitter output. | | | | | | | | | |

Table 2. TECHNICAL CHARACTERISTICS (Cont'd)

| <u>Item</u> | <u>Description</u> |
|--------------------|---|
| Synchronization | Prior to each new data transmission, two sync characters are transmitted. |
| Ready Level Output | The transmitter generates a ready voltage (-3 volts) for data source when ready for new data. |
| Timing Output | Bit and character timing pulses (-3 volts into 150 ohms). |
| Dimensions: | <u>Rack Mounted</u> <u>Transit Case</u> |
| Height | 3-1/2 inches 3-7/8 inches |
| Width | 19 inches 19-7/8 inches |
| Depth | 20 inches 22-7/8 inches |
| Weight | 19 pounds 35 pounds |
| Power Requirements | 115-volt, 50/60-cps, single-phase ac. |
| Power Drain | 20 watts (approx.). |
| RECEIVER: | |
| Input | Frequency-shift modulation. |
| Data Input | Serial bits: |
| | Character Data <u>Zero</u> Data <u>One</u> Rate |
| | 150 and 75 1200 cps 2400 cps |
| | 9.375 1232.5 1317.5 cps cps |
| Input Bit Rate | 1200, 600, or 75 bps. |
| Input Levels | -10 dbm to -36 dbm or 0 dbm to -26 dbm, switch selected. |
| Input Impedance | 1200 ohms with c. t. at 300 ohms; 600 ohms with c. t. at 150 ohms. |

Table 2. TECHNICAL CHARACTERISTICS (Cont'd)

| <u>Item</u> | <u>Description</u> |
|--------------------------|--|
| Data Output | 8 parallel bits, and serial data outputs available. |
| Levels | 0 and -3 volts into 150-ohm lines at each output. |
| Logic | -3 volts; data <u>one</u> . 0 volts; data <u>zero</u> . |
| Parallel Output Bit Rate | 150, 75, or 9.375 bps per parallel line. |
| Serial Bit Rate | 1200, 600, or 75 bps at serial line. |
| Delay Equalizer at Input | Provides variable compensation for delay distortion. |
| Strobe Output | Strobe pulse (-3 volts into 150 ohms) applied to data sink when new data available. |
| Timing Outputs | Bit and character timing pulses (-3 volts into 150 ohms). |
| Dimensions | <u>Rack Mounted</u> <u>Transit Case</u> |
| Height | 3-1/2 inches 3-7/8 inches 19 inches 19-7/8 inches 20 inches 22-7/8 inches |
| Power Requirements | 115-volt, 50/60-cps, single-phase ac. |
| Power Drain | 25 watts (approx.). |

5. Over-all Conclusions

The following general conclusions can be drawn from results obtained during the contract period.

a. F. M. data transmission at 1200, 600, and 75 bps over different voice channels has been successfully demonstrated.

b. Rapid automatic synchronization of transmitter and receiver have been demonstrated. This development makes "on-off" tactical net operation of the transmitter practical.

c. The inclusion of the narrow-band FSK data-transmission capability in the higher-rate voice-band Digital Data Terminal AN/TYC-1 was proven to be feasible.

d. Problems arising during the development period have been successfully overcome.

e. Digital Data Terminal AN/TYC-1 (XC-3) meets or exceeds the requirements of the equipment specification.

6. Recommendations

While the present units have passed all tests, there are some areas where further consideration may be of value. These are discussed in the paragraphs below.

a. MARGINAL TEST.

(1) A marginal test feature was incorporated into the AN/TYC-1. It operates by reducing the +10 voltage supply to the digital circuitry when the unit is placed in the test mode. A recent study on marginal checking techniques* stages:

"Techniques generally employed throughout industry are of the supply-voltage variation type. When systems employing marginal checking have accrued sufficient field time to permit evaluation of its effectiveness, marginal checking did not appear to have significantly enhanced the reliability of performance of these systems. The reason for this is that most of the systems employing marginal checking were so severely derated that drift failures were practically nonexistent. Thus, any failures that did occur in these systems were catastrophic, and the techniques employed were incapable of detecting or predicting such failures. However, as a debugging tool and detector of intermittents, marginal checking has been found to be of inestimable value.

"Finally, since experience with the equipments designed with severe derating showed that the incidence of faults due to drift is negligible as compared to that due to catastrophic failure, it appears that the incorporation of marginal checking is not warranted."

(2) This is in complete agreement with what STELMA has found since the inclusion of marginal testing in the TYC-1. If some benefit is derived, it is still difficult to justify this feature when attempting to balance it against the increased cost involved in inclusion of the more complex switching and wiring need.

b. SIMPLIFICATION OF SWITCHING FUNCTIONS.

(1) Impedance Switch. The function of the switch is to change the input/output transformer taps connected to the panel signal terminals,

*Marginal Checking Techniques Final Report (page 1-6) F. M. Barsam, RADC-TR-61-85, Burroughs Corp., Reference No. 681-61-336-L, February 1961.

in accordance with the input/output impedance requirements of the system. This switch could be eliminated by the simple expedient of bringing all five transformer taps to panel terminals.

(2) Rate Switch. Since the transmission rate is a system function, this switch setting might rarely be changed. The switch could therefore be removed from the front panel and made an internal adjustment. There is a disadvantage to this if a definite requirement exists to change the rate under tactical field operations. The operator would be required to remove the unit from its case in the field. This is inconvenient and may expose the equipment to dirt and water.

(3) Advantages. The benefits derived from the above would be twofold:

(a) Reduction of the size and complexity of the front-panel wiring harness would result. Therefore, fabrication costs would be reduced.

(b) Elimination of some front-panel wiring would tend to reduce noise pickup in the wiring harness. If the shielded wiring, presently included, could be eliminated, reduced materials and fabrications costs would result.

c. DYNAMIC RANGE. The present technical requirements specify operation over an input-level dynamic range of -10 to -36 dbm (with a switched, internal attenuator to shift the range to 0 to -26 dbm). The width of this dynamic range means to a situation may arise where, although a good signal (-10dbm) with a favorable signal-to-noise ratio (26db) is received, operation is impossible without an external attenuator. * It is, therefore, recommended that further study be made of the dynamic range requirements in the system. If the width could be reduced and the number of selected ranges increased, improved performance with poorer signal-to-noise ratios would result.

d. TEST AND EVALUATION PROGRAM. A rigorous test program to determine the operating capabilities of the AN/TYC-1 is highly desirable. Such a program should include measurement of error rate as a function of signal-to-noise ratio, delay distortion, and fading. Tests over various types of voice band communication channels are also desirable.

*With such a noise level, receiver would fail to recognize the no-transmission condition. It would not, therefore, resynchronize on each new transmission.

7. Identification of Key Personnel

a. ENGINEERING-HOUR DISTRIBUTION. A total of 7163-3/4 hours was charged to the project during the period covered by this report (25 October 1960 to 30 November 1961). Of this time, 6942-3/4 hours were distributed among Key STELMA personnel as specified in the following table.

| <u>NAME</u> | <u>TITLE</u> | <u>HOURS</u> |
|--------------------|----------------------------|--------------|
| Dr. N. Kramer | Project Manager | 214-1/2 |
| Mr. B. Krauss | Project Engineer | 450-3/4 |
| Mr. A. Brooks | Associate Project Engineer | 1783 |
| Mr. S. Schneider | Mechanical Designer | 407 |
| Mr. G. Mierzwa | Design Engineer | 235-3/4 |
| Mr. W. Kaszics | Design Engineer | 64-1/4 |
| Mr. A. Miranda | Printed-Circuit Engineer | 94 |
| Mr. L. Polis | Printed-Circuit Engineer | 609-1/2 |
| Mr. K. Hildebrand | Technician | 2079-1/4 |
| Mr. R. Aschenbrand | Technician | 1004-3/4 |

APPENDIX A

16 February 1961

MEMO

To: AN/TYC-1 Design and Application Personnel
From: Bert Krauss
Subject: Serial operation of AN/TYC-1 Digital Data Terminal

AN/TYC-1 (XC-1) is a parallel input parallel output terminal. The user need not concern himself with the order in which bits are transmitted or received. His only requirement is that the appropriate bits appear on the transmitter and receiver data leads. These leads are fully specified in "Fielddata Equipment Intercommunication Characteristics" 1 April 1959 (revised 1 August 1959) Page 51.

AN/TYC-1 (XC-2) and AN/TYC-1 (MOD) however, are parallel input-parallel and serial output terminals. In order to utilize the serial output at the receiver terminal the order in which bits are transmitted and received is important.

In the AN/TYC-1 (XC-1) design serial order was unimportant and the convenient order $PI_2I_1D_3D_2D_1D_0C$ was chosen. "C" is the first bit transmitted and received and "P" is the last. *

The order for serial data $PCI_2I_1D_3D_2D_1D_0$ (where D_0 is the first bit and P the last transmitted and received) is specified on Page 30 of "Fielddata Equipment Intercommunication Characteristics".

STELMA is arranging internal connections on AN/TYC-1 (XC-2) and AN/TYC-1 (MOD) to permit serial data to occur in this order. This change will not affect the parallel inputs or outputs in any way. No changes in the logic or circuits will be required.

Prepared by: Bert Krauss
Bert Krauss
Project Engineer

* In earlier literature generated by STELMA characters were written with the first bit on the left and the last bit on the right. In the future the convention will be right to left as in this memorandum.

APPENDIX C
FORWARD AREA DISPLAY UNIT
(FADU)

Final Report
by
Servomechanisms, Inc.



PUBLICATION 125

FORWARD AREA DISPLAY UNIT

REPORT NO. 5
CONTRACT: DA36-039-SC85146

FINAL REPORT
per PHILCO Specification
98 3333B and Revision 'C'
Dated 4/10/61

*This Fifth and Final Report
of the FADU Series Prepared for
PHILCO CORPORATION*

by
SERVOMECHANISMS/INC.

*Covers the Period
from
1 October 1961
to
9 March 1962
and
Summarizes the Entire Project*

SERVOMECHANISMS/INC.



SM/I Publication 125

FINAL REPORT TO PHILCO
on
FORWARD AREA DISPLAY UNIT
SM/I Type CTI 602

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Section 1

PURPOSE

The purpose of this contract is to design and fabricate two Forward Area Display Units per Philco Specification 9S 3333B and SM/I Proposal 83095. The FADU is a self contained, rugged, electro-mechanical indicating device to be used under field conditions by field artillery units to visually display fire control information at the firing position. The firing information is transmitted over existing wire and/or radio facilities from a digital computer.

The tasks are as follows:

1. Design and fabricate two (2) Forward Area Display Units, Parallel Input, SM/I Type CTI 602.
2. Prepare a final design plan per Philco Specification 9S 3333A.
3. Prepare instruction book per Philco Specification 9S 3333A.
4. Prepare itemized spare parts list.
5. Prepare shop drawings.
6. Prepare technical reports:

Four (4) Quarterly Reports and one (1) Final Report per
Signal Corps Technical Requirement SCL-2101K.

Monthly Reports during those months in which a Quarterly
Report is not submitted.

Section 2**ABSTRACT**

This report contains a resume' of progress made during the reporting period from 1 October, 1961, to 9 March, 1962, and summarizes work on the entire project from the start in October 1960 to its conclusion. References below correspond to the tasks enumerated on the preceding page.

Task 1 Design and Fabrication

Design of the two Forward Area Display Units is 100% complete. Fabrication of the first of these (S/N 1) is 100% complete and fabrication of the second (S/N 2) is 95% as of 9 March, 1962.

Task 2 Final Design Plan

The final design plan was submitted to Philco approximately 9 January, 1961 and was approved.

Task 3 Instruction Book

The instruction book has been written, is currently being prepared and will be delivered shortly.

Task 4 Itemized Spare Parts List

The spare parts list has been submitted to Philco.

Task 5 Shop Drawings

The shop drawings have been prepared in the course of the design and fabrication of the two units. They will be submitted to Philco with delivery of the second (S/N 2) Forward Area Display Unit.

Task 6 Technical Reports

Four quarterly reports have been submitted to Philco. Monthly reports have been furnished during those months that quarterly reports were not due. This document constitutes the final report.



Section 3

REPORTS AND CONFERENCES

3.1 Conferences

3.1.1 November 3, 1960

A meeting of SM/I personnel concerned with the FADU program was held at SM/I's Santa Barbara facility, at which design matters were discussed, agreement was reached on notations to be used and a list of questions was formulated to be answered by Philco. (Reference SM/I Memo 20: 24071.)

3.1.2 November 18, 1960

A telephone conversation was held between F. Laverghetta of Philco and E. Knell and N. Timares of SM/I. (Reference SM/I Memo 20: 24102.) Several questions with respect to the Philco Specification 9S 3333A were put to Mr. Laverghetta, seeking clarification of the specification's intent or meaning and requesting certain deviations such as replacing the "message indicator" with an indicator light. Some questions were answered at that time; others were left to be resolved later.

3.1.3 December 6, 1960

Copy of a memo from Philco's H. Glazer to F. Laverghetta was received at SM/I in which it was stated that an END-OF-MESSAGE character was to be added to the transmitted message.

3.1.4 December 7, 1960

A meeting was held at SM/I attended by F. Laverghetta as the Philco representative and by N. Timares, E. Knell, R. Walker, B. Hayden and F. Malek for SM/I. (Reference Memo 20:2414) Briefly, the items discussed were:

- a) The form of the END-OF-MESSAGE code.
- b) When the NEW MESSAGE indicator should be turned on.
- c) Different manner of operation between Error Mode and Test Mode.

- d) Characteristics of the applied voltage of the FADU.
- e) Form and content of forthcoming final design plan.

The amount of detail description of various circuits and components to be included in this final design plan was discussed. It was decided that matters concerning format of the final design plan would be determined at a later date.

3.1.5 December 14, 1960

A resume' of matters proposed by SM/I for inclusion in the final design plan was transmitted (Memo 60M861) to Philco.

On this same date a telephone conference was held between F. Laverghetta and SM/I's E. Knell and N. Timares (SM/I Memo 20: 24149) which covered the following subjects:

- a) Decision to use a green light in place of the Message Indicator.
- b) Code for the NEW MESSAGE light changed to Address #26.
- c) Design of the Test and Error circuits, as discussed at the meeting at SM/I on December 7, to be done in accordance with SM/I Memo 20: 24146.

3.1.6 December 20, 1960

A message was received from Philco concurring with the SM/I resume' of contents for the final design plan (Memo 60M861) as mentioned in Paragraph 3.1.5 above.

3.1.7 December 21, 1960

A telephone conference was held with Philco representatives H. Glazer and G. Forman (Reference SM/I Memo 20: 24163) during which SM/I personnel asked such questions as:

- a) What the FADU Alternate Address would be.
- b) What would be the characteristics of the input a. c. voltage.

- c) Whether it would be permissible to use neon lamps for indicator lighting.
- d) What the color of the FADU would be.

The reply was that these matters were not yet determined and answers would be transmitted to SM/I later. Since Mr. Laverghetta had taken back with him from the December 7th meeting the mechanical layouts of the FADU, SM/I asked for comments on the packaging indicated. The reply was that everything appeared to be satisfactory.

3.1.8 January 3, 1961

A telephone conversation between Laverghetta and Timares covered the subjects of coating of boards, indicating lights, alternate address and the color of the FADU case. (Reference SM/I Memo 20: 24169.)

3.1.9 January 5, 1961

A telephone conference between Philco's H. Glazer and SM/I's E. Knell and N. Timares discussed the problem of receiving a data character greater than 9 and SM/I was considering making modifications to prevent the receiving of such characters. Philco mentioned the possibility of filler characters being sent to the FADU. (Reference SM/I Memo 20: 24175.) However, at the present time, the FADU is designed to recognize a filler character as a data character and some changes would be necessary for this to be recognized and disregarded.

3.1.10 January 19, 1961

A telephone conference involving Glazer and Laverghetta for Philco and Knell and Malek for SM/I took place. SM/I was informed that, in general, the First Quarterly Report and the Final Design Plan appeared reasonable, though some questions regarding circuit details were raised. F. Malek clarified details of circuitry to the satisfaction of H. Glazer. SM/I was advised to expect a visit from the Fort Monmouth Project Engineer on January 26, 1961.



3.1.11 January 26-27, 1961

A meeting was held at SM/I including H. Glazer of Philco, Lieutenant Enslow of Ft. Huachuca and J. Cox of Ft. Monmouth, described in SM/I Memo 20: 24214 and Appendix A of the Second Quarterly Report.

3.1.12 February 8, 1961

A meeting between SM/I representatives and Philco personnel was held at Philco concerning SM/I requests for additional funds.

3.1.13 February 16, 1961

A telephone conference between Glazer and Knell was held to discuss topics considered at the January 27, 1961 meeting. Results of this conversation are described in SM/I Memo 20: 24239 in Appendix A of the Second Quarterly Report.

3.1.14 February 27, 1961

A telephone conference was held between Glazer and Knell regarding color, captive screws and other subjects. Results are reported in SM/I Memo 20: 24246 in Appendix A of the Second Quarterly Report.

3.1.15 March 22, 1961

A telephone conference was held between Glazer and Knell regarding logic diagram, panel markings, color and other subjects. Results of this discussion are given in SM/I Memo 20: 24277 in Appendix A, Quarterly Report No. 2.

3.1.16 July 20, 1961

Transcript of a telephone conversation between H. Glazer of Philco and S. Berkowitz of Philco, with copies sent to SM/I.

3.1.17 July 21-24, 1961

H. Glazer visited SM/I, during which time he received a letter from Philco Corporation which became a part of this file, as well as a memo submitted by SM/I to Glazer on July 24 concerning the Ready Line.

3.1.18 July 26, 1961

A telephone conversation between D. Biles of Philco and E. Knell of SM/I.

3.1.19 September 25, 1961

Memo to H. Glazer of Philco from E. Griffin of SM/I indicating test results.

3.1.20 December 5, 1961

A telephone conversation between Glazer and Griffin regarding the status of the first (S/N 1) Forward Area Display Unit provided Glazer with the information that a principal problem at the time was delivery of the logic modules. The 100-hour test was also discussed.

3.1.21 December 8, 1961

A report on the proposed 100-hour test was transmitted by SM/I to Glazer at Philco. (Reference SM/I Memo 20: 24540.

3.1.22 December 14, 1961

A telephone call from Glazer to Griffin informed the latter that Glazer would be at SM/I on the morning of December 18th to witness the acceptance on the first (S/N 1) FADU CTI 602, and that he would be accompanied by other Philco personnel for witnessing the 100-hour life test.

3.1.23 January 2, 1962

Telephone conversation from Griffin to B. Atcheson of Philco, in Arizona, concerning difficulties encountered

in the 100-hour test of S/N 1. These matters are delineated in SM/I Memo 20: 24573.

3.1.24 February 6, 1962

Telephone conference between Griffin and Knell of SM/I and Glazer of Philco to discuss results of Systems Test on S/N 1. (Reference Memo 20: 24627.)

3.1.25 February 7, 1962

Telephone call from Glazer to Griffin to request certain spare indicators. The results of this conversation are set forth in SM/I Memo 20: 24628.

3.2 Reports

During the course of this project Quarterly and Monthly Reports have been submitted to Philco by SM/I. Principal documents in this series consist of:

First Quarterly Report, covering the period from October 28, 1960, to December 31, 1960.

Final Design Plan, discussed at the conference of January 26, 1961, referred to in Paragraph 3.1.11 above.

Second Quarterly Report, covering the period from January 1, 1961, to March 31, 1961.

Test Plan for Forward Area Display Unit CTI 602, submitted April 19, 1961.

Third Quarterly Report, covering the period from April 1, 1961 to June 30, 1961.

Fourth Quarterly Report, covering the period from July 1, 1961 to September 30, 1961.

Final Summary Report, covering the period from October 1 to conclusion of the project and recapitulating the entire program, submitted March 22, 1962.

Section 4**FACTUAL DATA**

The design of the Forward Area Display Unit consists of four phases. These are the Electronics Circuit, the Power Supply, the major Mechanical Design and the Indicator Design and Fabrication.

4.1 Electronics Circuit Design

The logic design of the CTI 602 was essentially completed in November and December of 1960 though it has been slightly revised since that time as necessary. The circuits were designed during the first and the early portion of the Second Quarterly Reporting Periods.

The circuits were designed from a theoretical basis and were proven by laboratory tests. All circuits were breadboarded and tested out with temperature and voltage extremes. Since that time the only changes made were those necessitated by additions to the requirements, such as the ready line and the error circuits, or changes which became evident during the testing program, such as dealing with the creep problem. The total circuits have involved very few difficulties in view of the amount of circuitry present. The problems which arose were of a design nature such as changing of component values where necessary or adding a capacitor to eliminate noise. This was the extent of most circuit alterations. Figure 1 is the Logic Diagram of the CTI 602.

4.2 Power Supply Design

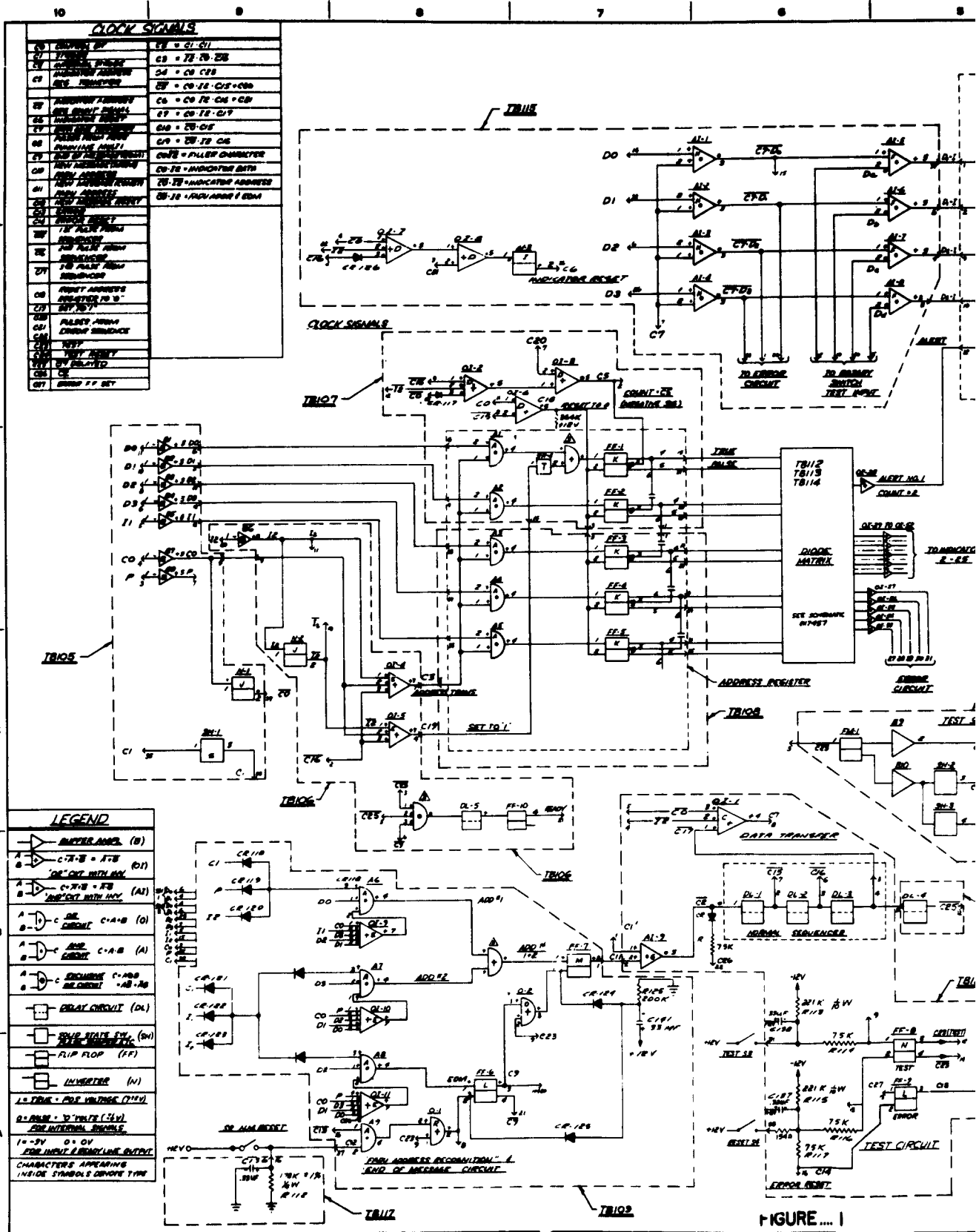
The 12 volt power supply was designed during the First Quarterly Period and the design has not been changed in any way. The final power supply carries out the original 12 volt design. See Figure 2.

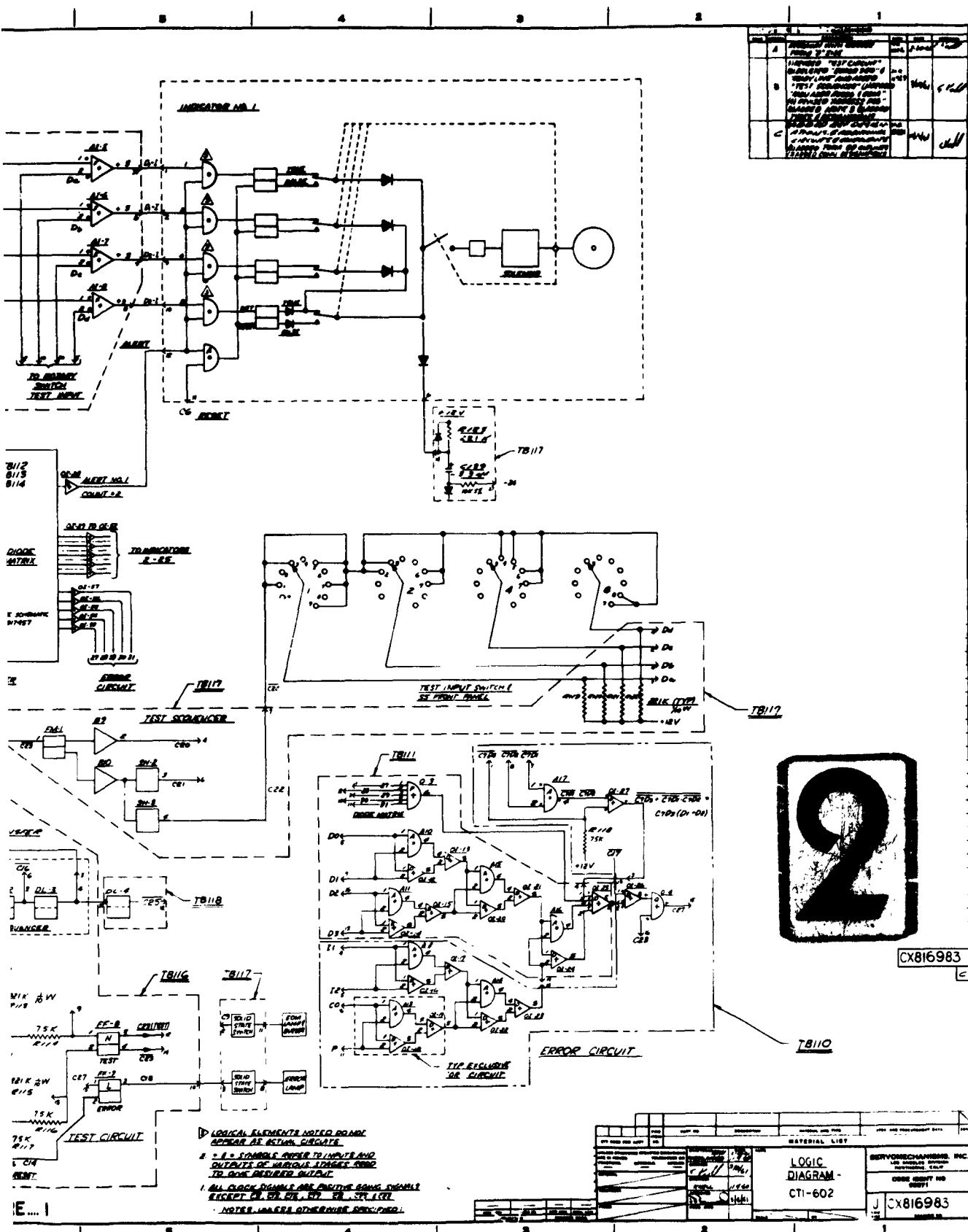
The indicator power supply, also referred to as the 85 volt power supply, was likewise designed during the first period and was breadboarded at that time. Its requirements were (1) that approximately 85 volts had to be supplied to the solenoids and (2) that negative spikes had to be supplied to the anode of the Silicon Controlled Rectifier, or SCR, in the indicator so the power could be turned off. The SCR is a device which can be turned on with a positive signal on its gate but

cannot be turned off until the driving power is removed. The method used in this instance to remove power was, essentially, putting a negative spike on the anode of the SCR.

In the original design and the first breadboard a DC power supply was used to provide the 85 volts. An oscillator circuit was designed and breadboarded which put out the negative spikes. The spikes were coupled through a capacitor into the anode of the SCR. The indicator was connected and was operated from this power supply and performed to satisfaction. This method of making the power supply had kept the DC power supply separate from the spikes. A problem developed later when the oscillator had to supply negative spikes to a bank of 25 indicators. With the original breadboard circuit, operation was satisfactory when only three or four indicators were being driven. While the load was increased and all indicators were being supplied with power the oscillator became overloaded. Different oscillator circuits were tried in an attempt to supply the oscillator power to all of the indicators at once. None of these proved successful. The circuit that ultimately evolved from all the breadboarding and testing was one which has a different oscillator as part of the DC power supply. It supplies spikes superimposed upon the DC level. As a result of this work, the final supply has the 85 volt DC level superimposed with spikes, which dropped the voltage down to zero and then allowed it to build up again.

When this circuit was redesigned, another problem developed with the power supply. It seems that the first SCR used required any negative signal at its anode to allow the SCR to be turned off. The next few that were operated from the new supply with the spikes in it required any negative signal dropping to zero on the anode to turn the SCR off. But when the first production logic assemblies arrived, with their own SCRs, a new problem became apparent. These SCRs seemed to be critical as to the type of spike which would turn them off. Specifically, the width of the pulse at zero and also the rise time in which the pulse builds up again to 85 volts was critical. If the rise time was too short the SCR could be inadvertently turned on again when it should not be. Checking with the manufacturer of the SCRs led to the conclusion that the vendor did not know his product very well. The pulse width presently being used is about 450 microseconds. (This is roughly 10 times the manufacturer's recommended turn-off time.) After reaching these conclusions the supply was breadboarded and tested under temperature extremes. Its performance was satisfactory and has continued so.





| NO. | DESCRIPTION | REV. | DATE | BY |
|-----|-------------|------|--------|----|
| 1 | REVISION 1 | 1 | 1/1/68 | J |
| 2 | REVISION 2 | 2 | 1/1/68 | J |
| 3 | REVISION 3 | 3 | 1/1/68 | J |



CX816983

| MATERIAL LIST | | SERVOMECHANISMS, INC. | |
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| Q99 | AND GATE | Q99 | AND GATE |
| Q100 | AND GATE | Q100 | AND GATE |

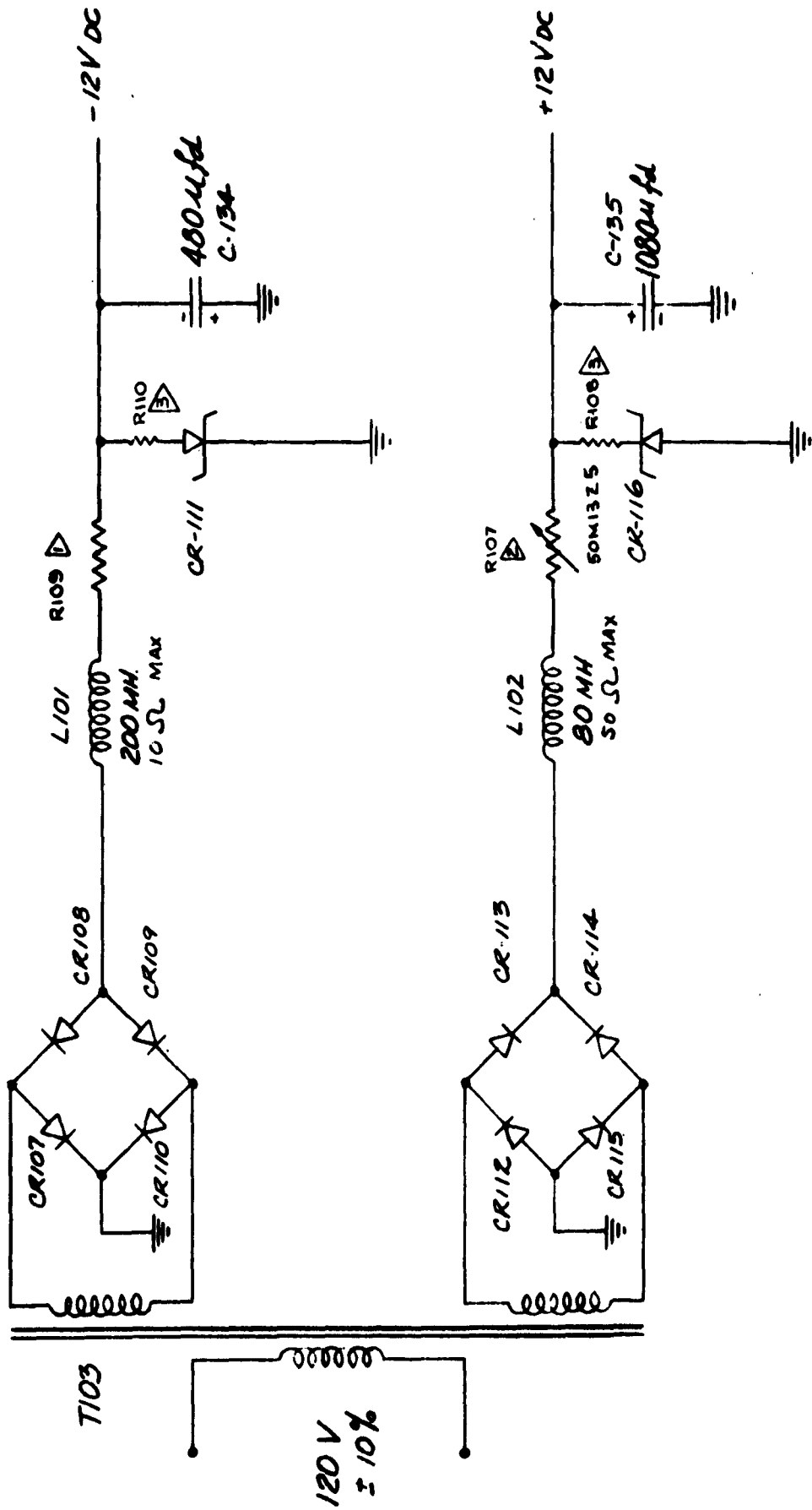


FIGURE 2....SCHEMATIC, ± 12 VOLT POWER SUPPLY

One further change in the power supply occurred as the indicators were being redesigned and consequently required more power. The output voltage of the indicator power supply was raised. As presently used, the output voltage is 120 V, \pm 20 V. The 17% fluctuation is due to the 10% line fluctuation plus whatever may result from the indicators in operation, which may vary from one through six. The frequency of the oscillations is 250 cps. (See Figure 3.)

4.3 Mechanical Design

The Forward Area Display Unit consists of an inner chassis assembly shock-mounted to the outside transit case, as shown in Figure 4. The external carrying case is waterproof when the front and back covers are on and, by being shock-mounted, any shocks due to handling or falling are isolated from the inside case. The inner case is a welded assembly containing the 25 indicators and all electronics necessary for driving them. During operation, the front and back covers are removed. Removal of the rear cover permits the cables and connectors to be attached to the FADU. Removal of the front cover permits operating and viewing the FADU. Design of the inner case was accomplished during the First Quarterly Reporting Period and the early part of the Second. Very few problems were encountered.

One change, however, occurred in increasing the size and weight over the original estimate. Another design change occurred with respect to the carrying case. The original concept had the front cover removable as described above but the rear cover was solid, with the signal and power connectors brought out through a rubber boot. The redesigned case has a removable cover on the back as well as front, which permits isolating the connectors from shock should the unit be dropped in transit.

The internal design of the unit consists of a box essentially divided into three parts. The front portion, which contains approximately 60% of the volume, accommodates all 25 indicators with additional space for 4 more. These indicators are all plug-in modules which are inserted from the front of the unit after removing the internal face plate, or front panel.

In the face panel, which is connected to the main unit by a harness, there are windows for viewing the indicators and on the panel mounted the power ON-OFF switch, the Rotary Test switch and three push-button

switches for Test, Test Reset and New Message Reset. The face panel also carries the lamp which indicates Power ON, the New Message lamp and the Test and Error lamp. Procedure for replacing indicators is, first, to take off the face panel by removing 16 screws and then removing the two screws which fasten each of the indicators in place.

Of the remaining 40% of the volume, approximately three-fourths (30% of total volume) is taken up by the 12 plug-in boards and the indicator power transformer. These plug-in boards contain all the electronics which are not integral parts of the indicators themselves.

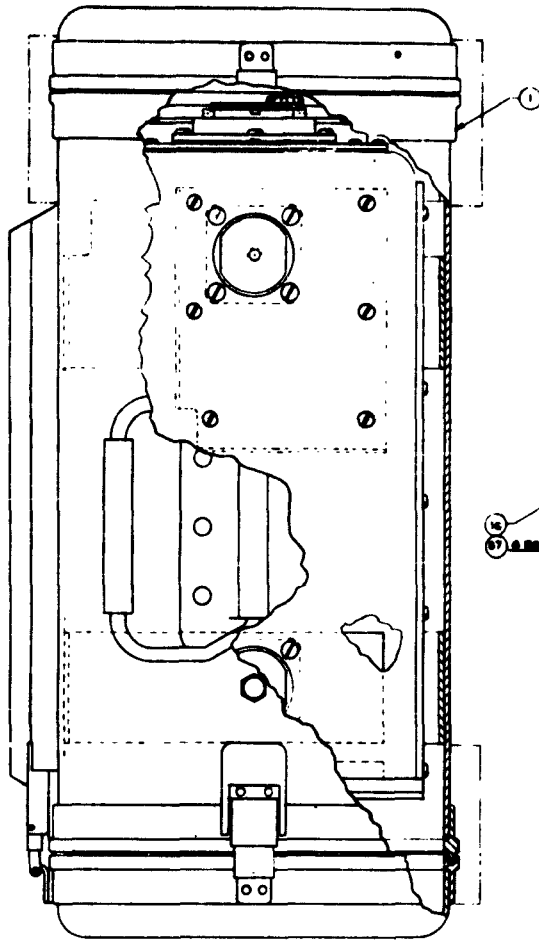
The rest of the space, which is in the lower portion of the unit, is occupied by the transformers and associated circuitry for the 12 V power supply and the indicator power supply. Figures 5 and 6 are top and bottom views of the FADU with the covers removed. Figure 7 shows a typical circuit board assembly before connector potting.

4.4 Indicator Design

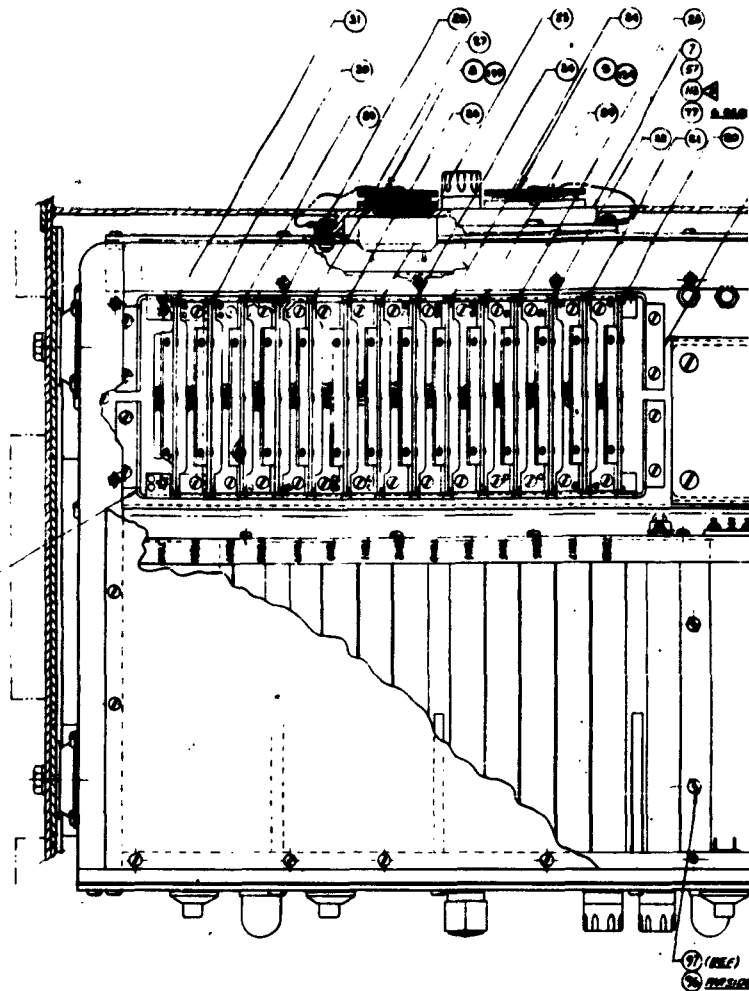
4.4.1 Indicator Logic Design

The design of the indicator logic circuits was accomplished during December of 1960 and underwent a few minor modifications shortly thereafter. The modifications consisted of providing the means to set the indicator flip-flops when the power is first turned on, and also to prevent any binary code representing a number greater than 9 from entering. In addition to these early modifications, other changes occurred later in the matter of indicator logic design. One of these was the addition of a capacitor to reduce noise pick-up in the production logic assemblies. Another problem solved with the present indicator was the setting of flip-flops when the reset signal entered. The reset signal normally reset all the flip-flops but occasionally, as the signal was leaving, the trailing edge would "set" a few flip-flops. This did not occur often but when it happened the first time the problem was investigated and correction was instituted. An RC network was added to the output of the reset gate. This increases the time constant of the trailing edge and eliminates the problem.

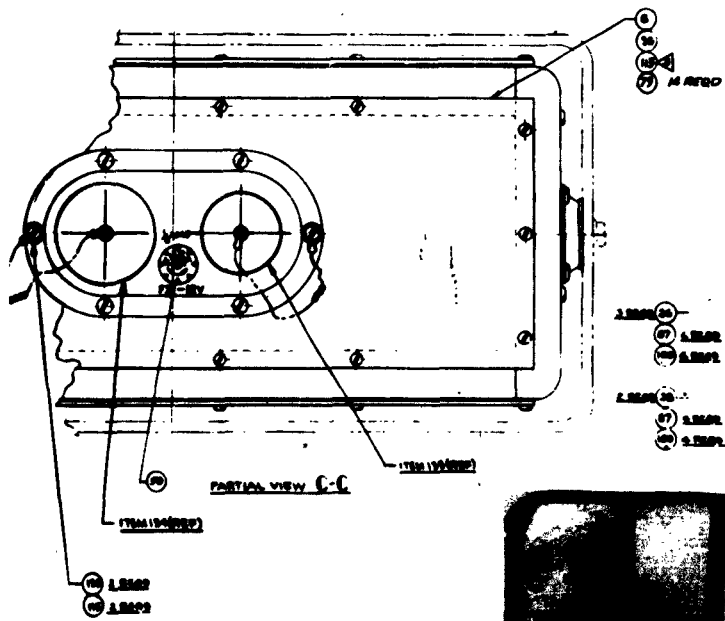




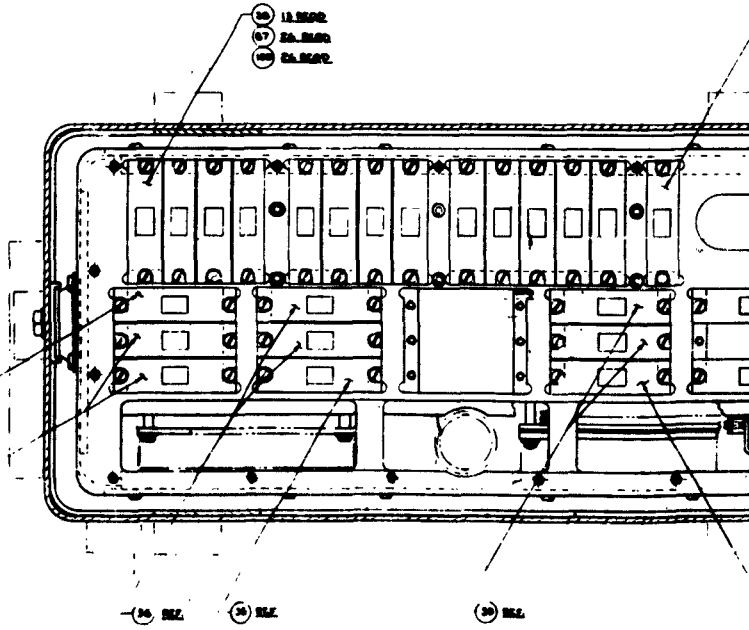
37 A.M.P.



37 (REL)
38 (REL)



37 A.M.P.
38 A.M.P.
39 A.M.P.
40 A.M.P.
41 A.M.P.



36 A.M.P.
37 A.M.P.
38 A.M.P.

36 REL
37 REL
38 REL

VIEW WITH ITEM 32 REMOVED

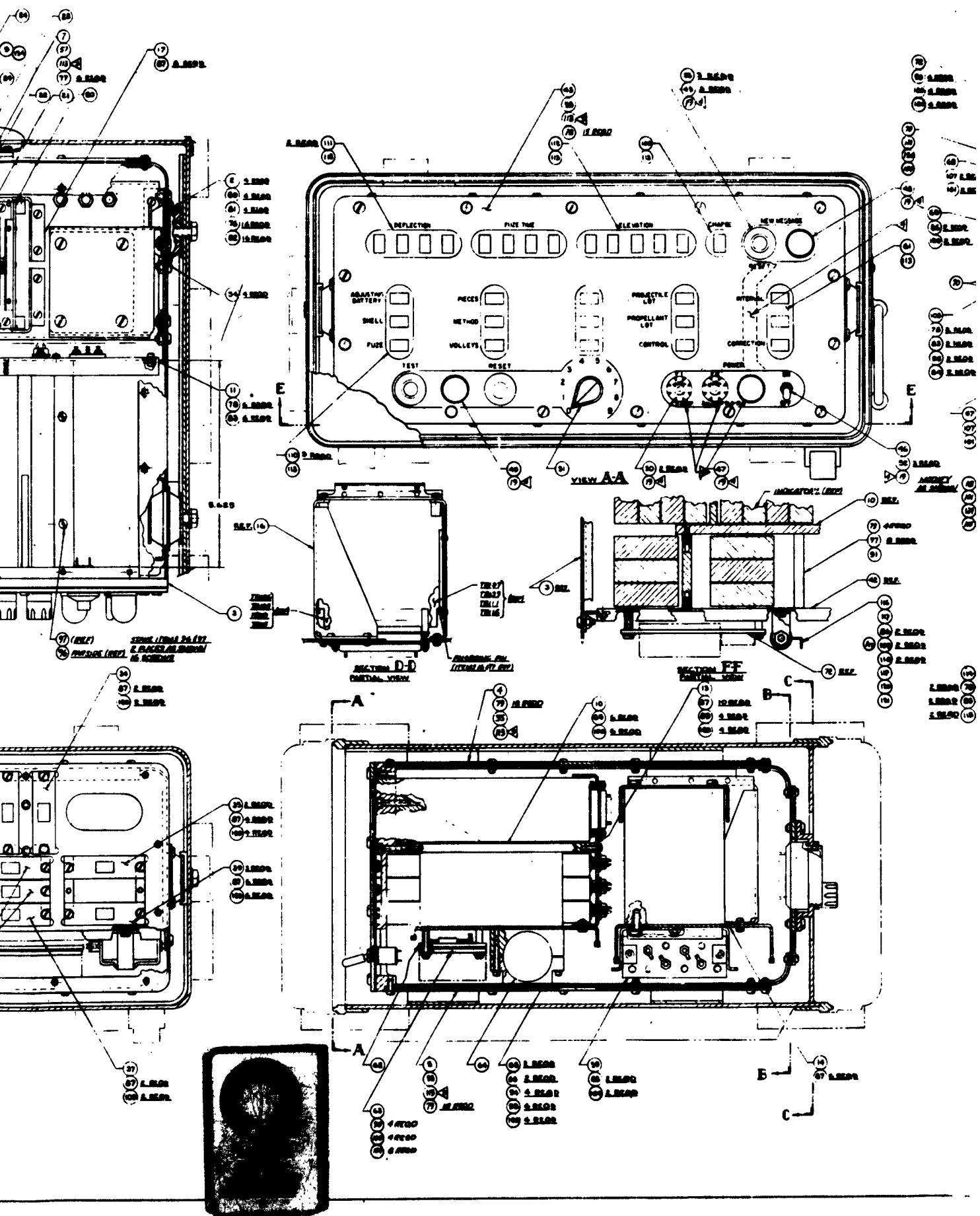




FIGURE 4

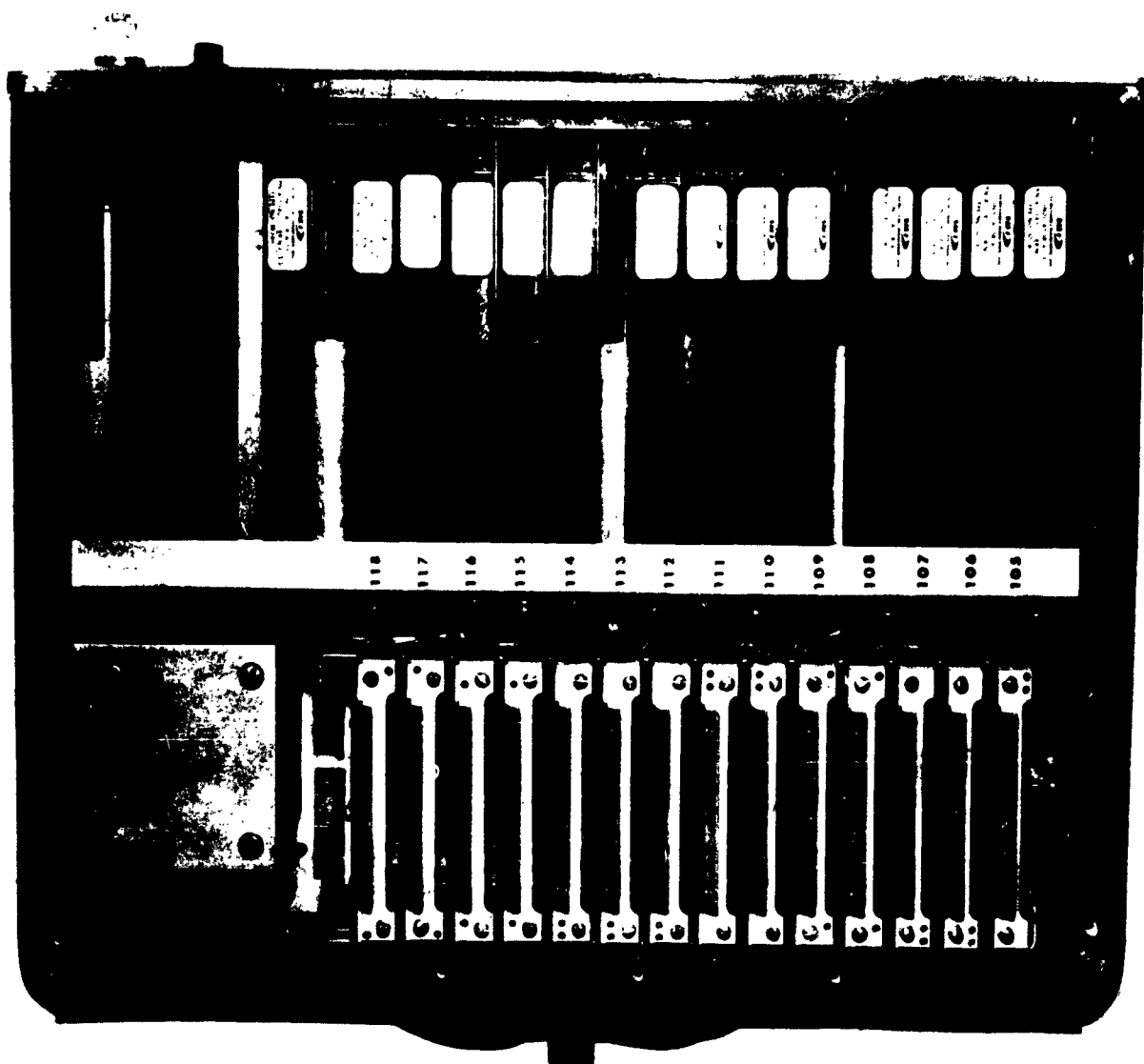
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| 1 | 100 | MS3050-000 | LOCK NUT | | |
| 2 | 100 | MS3050-001-6 | LOCK NUT SEAL | | |
| 3 | 100 | MS3050-002 | CAPSCREW | | |
| 4 | 100 | MS3050-003 | CAPSCREW | | |
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| 6 | 100 | MS3050-005 | CLAMP | | |
| 7 | 100 | MS3050-006 | CLAMP | | |
| 8 | 100 | MS3050-007 | CLAMP | | |
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| 1 | 9 | 16-4-100-001 | CONNECTOR | | AMPHENOL - CHICAGO, ILL |
| 1 | 9 | 17110 | HOUSING - CNA | | |
| 1 | 9 | 17111-1 | COVER - REAR | | |
| 1 | 9 | 17112 | COVER - BOTTOM | | |
| 1 | 9 | 17113-1 | COVER - TOP | | |
| 1 | 9 | 17114-1 | CHASSIS - ASSEMBLY | | |
| 1 | 9 | 17115 | ISOLATOR | | |
| 1 | 9 | 17116-1 | CASE | | |

**SEPTENNARIUM/INC.**

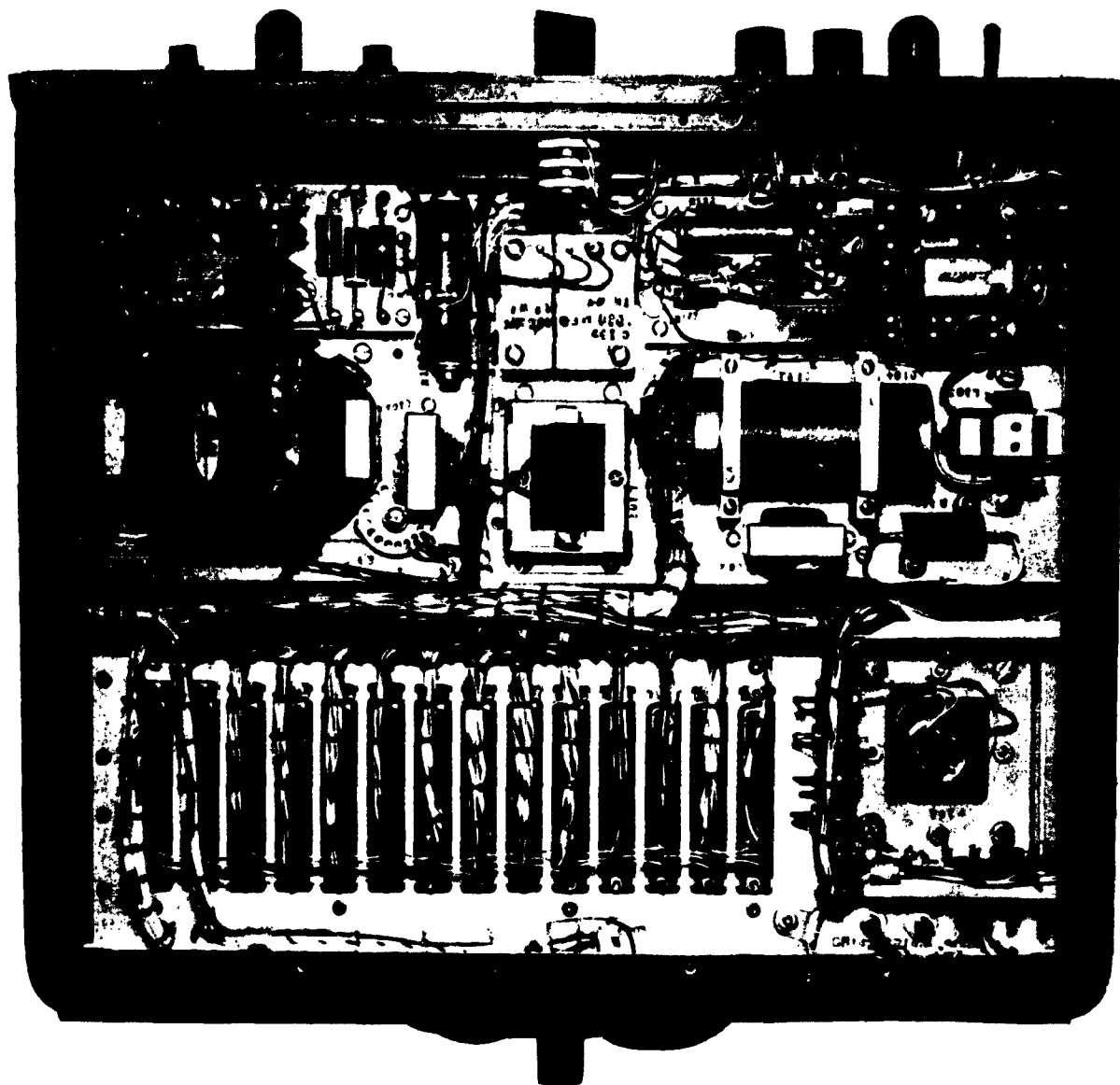


FIGURE 6....BOTTOM VIEW-COVER REMOVED

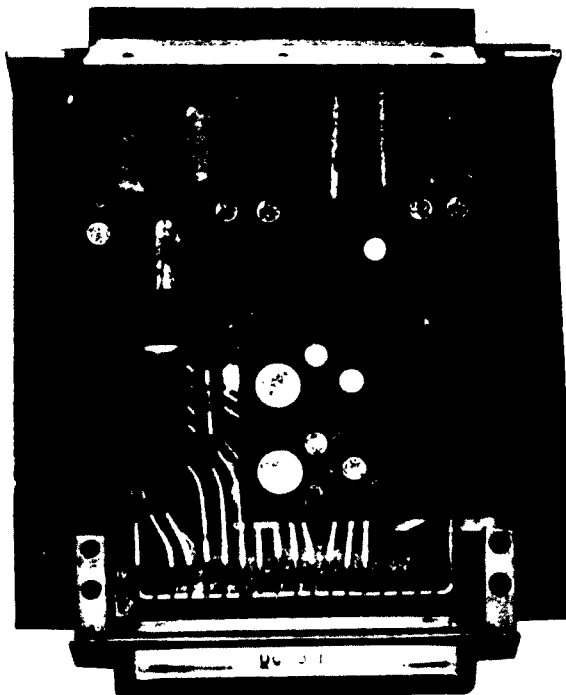
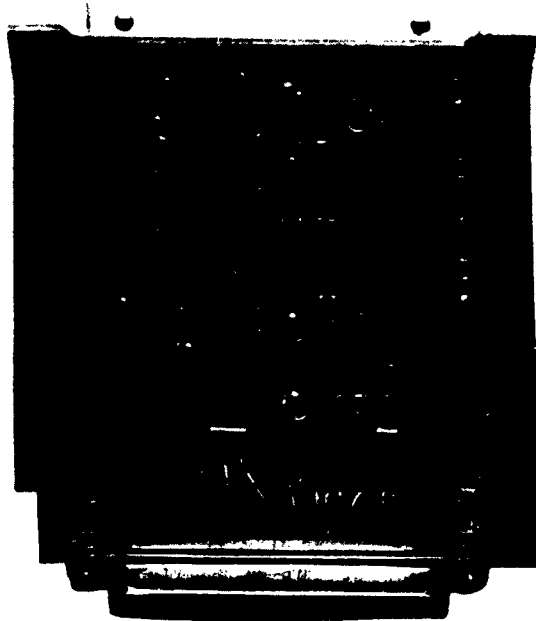


FIGURE 7...TYPICAL CIRCUIT BOARD, BEFORE CONNECTOR POTTING

Figure 8 provides a schematic of the indicator and Figure 9 is a photograph of the indicator assembly.

4.4.2

Mechanical Design

The mechanical design of the indicator is the aspect of the project which posed the principal difficulties. The indicator consists essentially of a housing, logic assembly, solenoid, pawl, wheel and switch as the chief items. Upon receiving a signal from the logic assembly through the switches, the solenoid is actuated in a stroking manner causing the pawl to revolve the wheel until the wheel is correctly positioned to agree with the number commanded by the logic assembly. This construction of the indicator was proposed during the early part of 1960 and became the basis for the design. When the indicators were fabricated certain problem areas became evident, namely (1) the switch, (2) the pawl, (3) the wheel and (4) the solenoid and solenoid mounting arrangement.

4.4.2.1

Wheel

The wheel, shown in the Figure 10 drawing, is made of Delrin, a DuPont plastic material. Milk-white is the color used for this application, with black paint coating the outside surface of the wheel in such a manner that numerals show white against a solid black background. The wheels are made by forcing the molten Delrin into a mold at high temperatures and letting it cool until firm.

The first problem with the wheel was that of painting the wheels so that the numerical symbols were clearly legible and accurately placed. The vendor found it necessary to try several methods before arriving at one that proved consistently satisfactory.

After evolving a dependable painting and drying process which produced a good lasting finish, a second problem appeared. The painting process

required that the wheel be soaked at a temperature of 170° F. This resulted in an additional shrinkage, over and above the normal molding shrinkage for Delrin, in this case approximately .010 in. across the width of the wheel. Delrin literature showed that it should withstand a temperature of 185° F continuously without showing any deterioration. However, tests proved that Delrin actually would shrink beyond its stated normal molding shrinkage when subjected to temperatures no higher than 140° F. The method ultimately settled upon involved soaking the wheels for two hours at a temperature of 180° to anneal them. Thorough investigation of other potential materials discovered nothing as desirable as Delrin for optimum characteristics in this service.

The third problem in connection with the wheel was the cam indexing. An analysis of the pawl was performed several months after the pawl was originally designed and it became evident that the required switch length for the pawl was not the same as the effective cam length on the indicating wheel. As seen in Figure 11, the effective cam length is the actual length of the flat surface on the cam plus the additional overtravel needed on either side to make and break the switch. The original pawl had been designed to the actual cam length and it was necessary to redesign it to the effective cam length, with the result that the indexing of the cam surface had to be changed slightly. This was done by having the base (or bottom portion) of the wheel mold rotated about the center 2° with respect to the top portion of the mold. This had the effect of rotating the cam surface with respect to the wheel as a whole, and it required a minimum rework of the wheel molds.

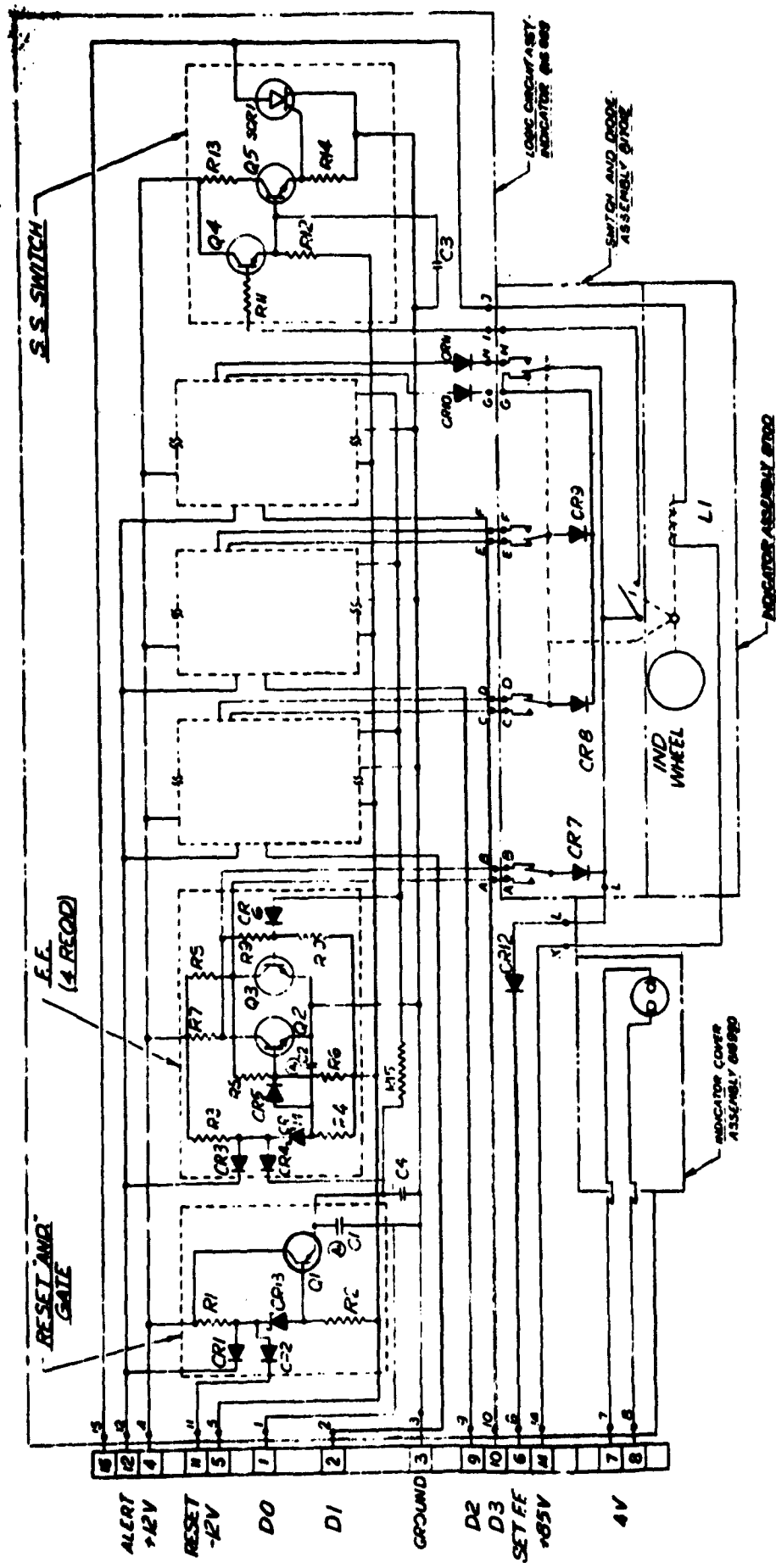


FIGURE 8... SCHEMATIC, INDICATOR ID 2005

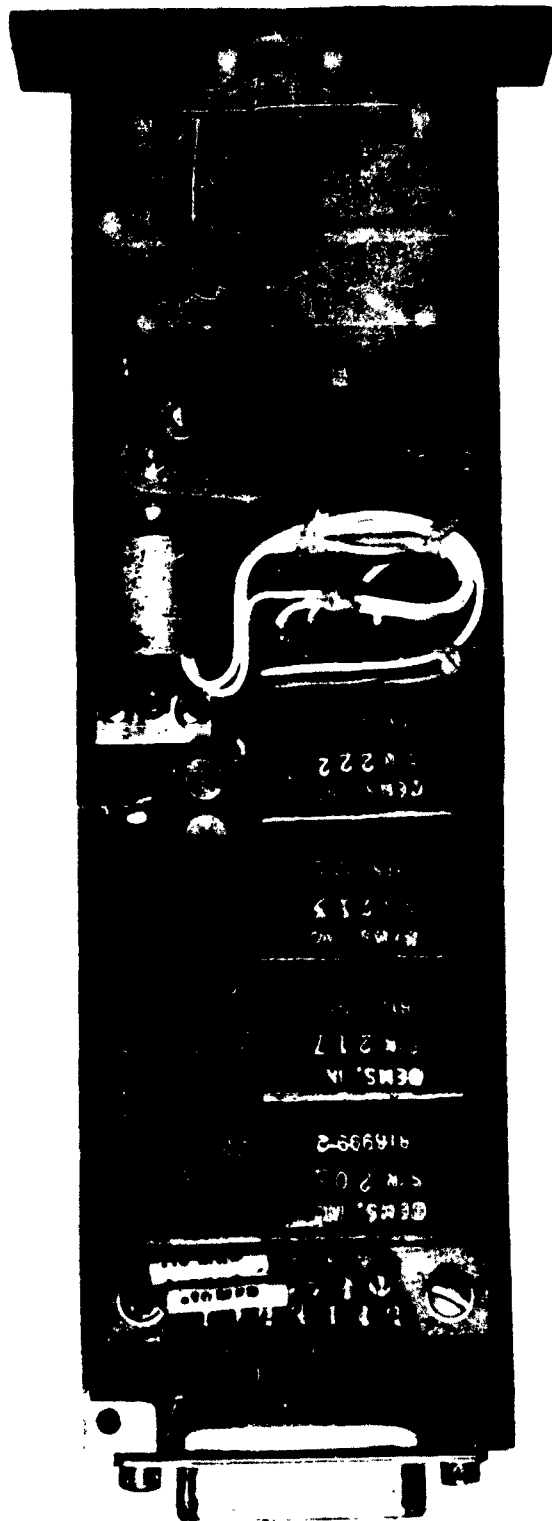


FIGURE 9...INDICATOR ASSEMBLY

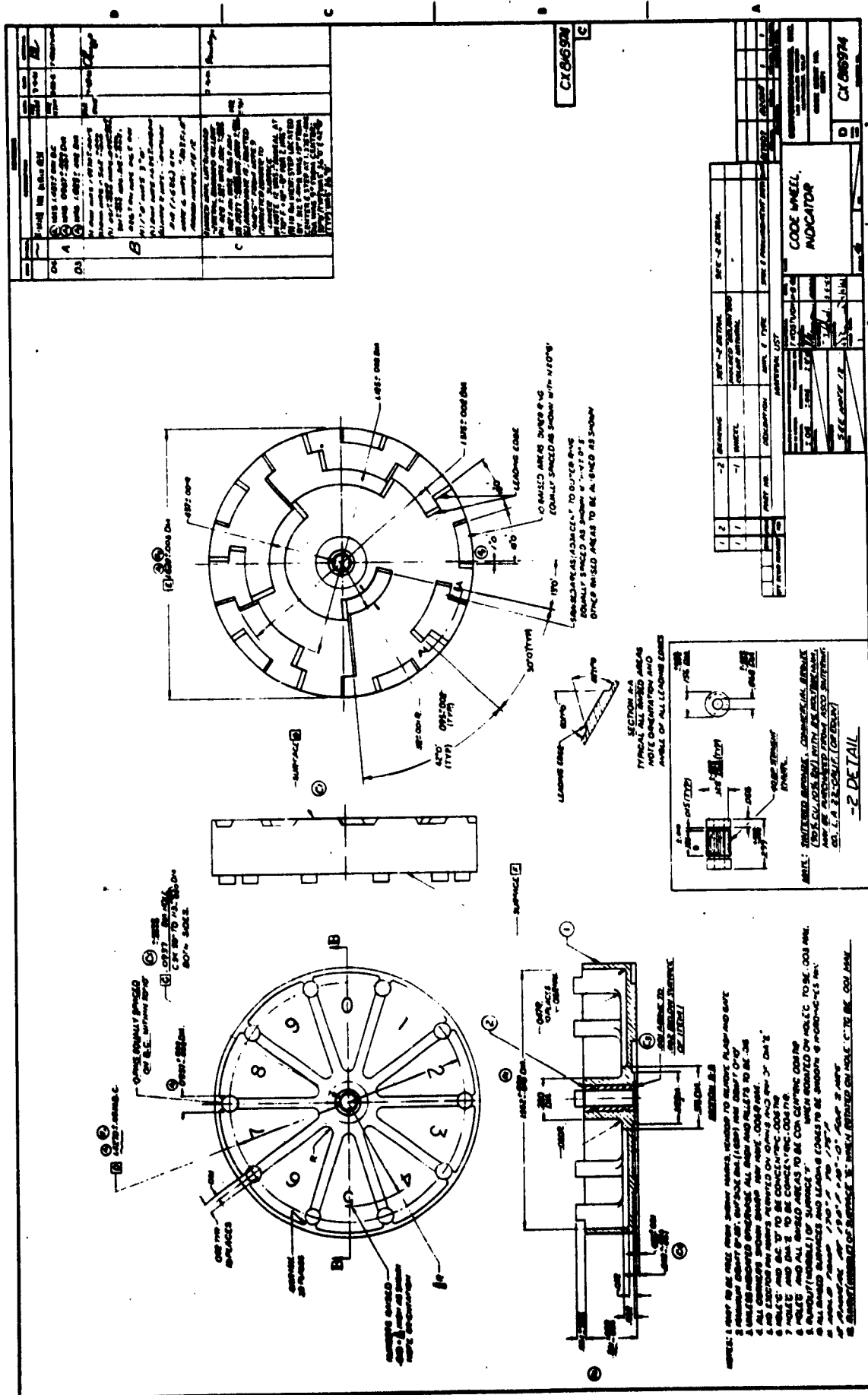
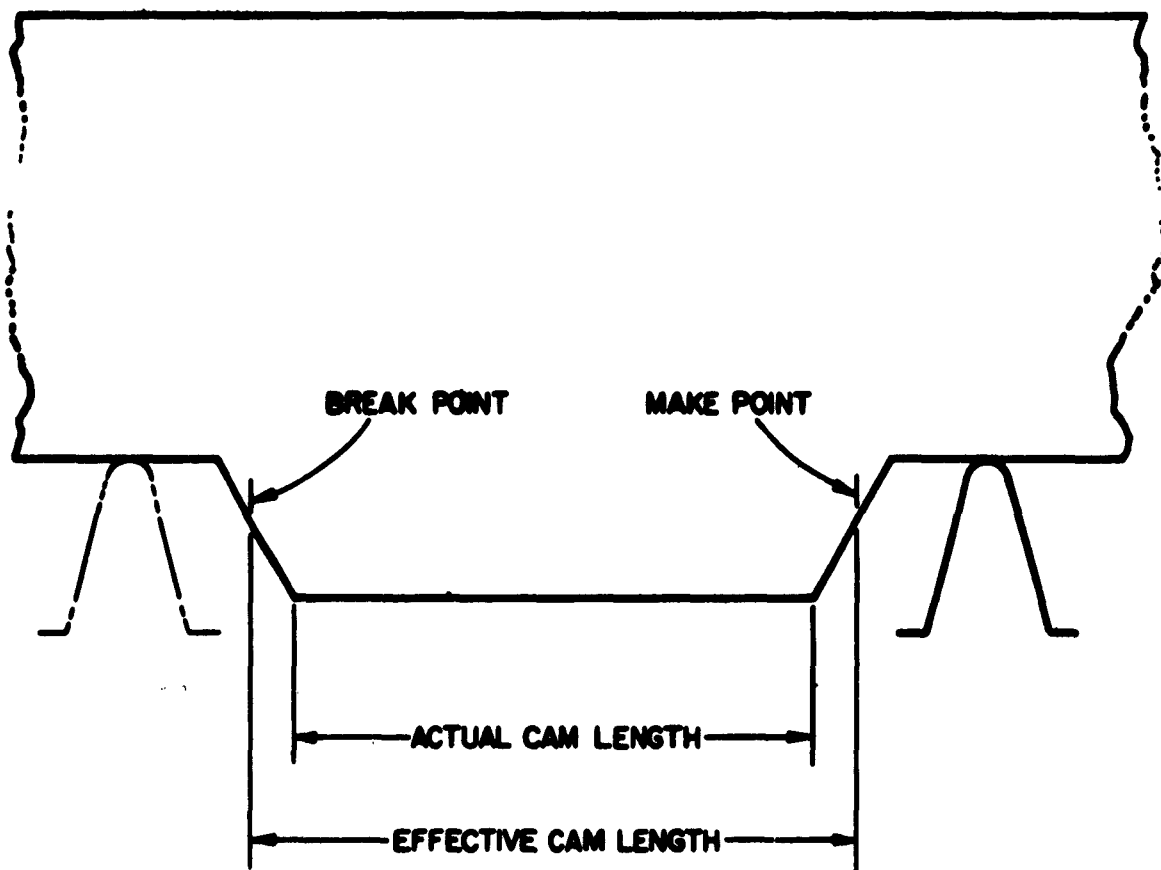


FIGURE 10... CODE WHEEL INDICATOR



ILLUS. NO.
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PUB 125

FIGURE 11...CAM LENGTH

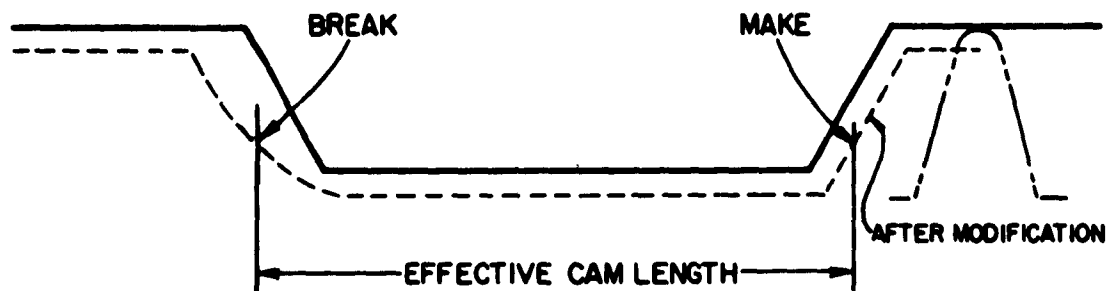
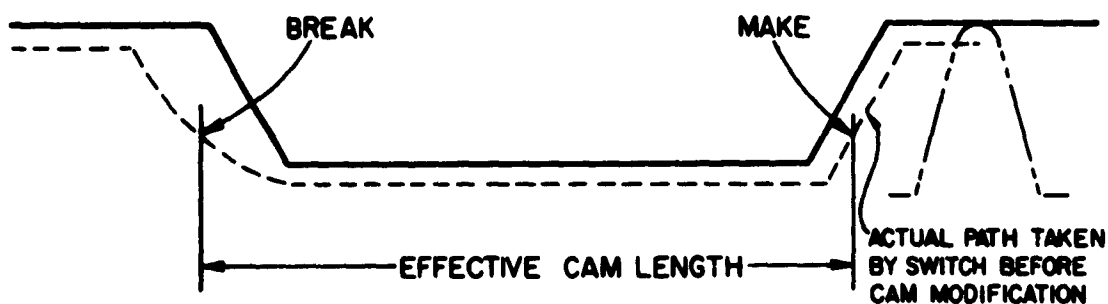
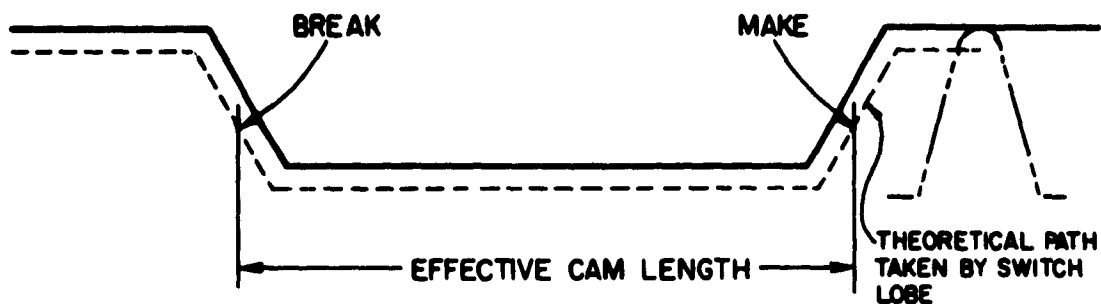
A fourth problem related to the wheels concerns the method by which they were molded. The wheel mold was gated from one side rather than from the center. This produced wheels which were slightly eccentric, or egg-shaped, with a major and a minor diameter. The out-of-round condition had the effect of using up all available tolerances on other mating parts of the wheel. However, in view of the project schedule, it was decided to use the wheels and rework the parts affected, rather than alter the mold to provide center gating, which would have involved an unacceptable delay in delivery of the units.

The fifth wheel problem had to do with the flatness of the cam surfaces. After molding, the flatness of the cam surfaces was found to vary .004 to .005 in., which is too much to allow for easy adjustment and caused great difficulty in shimming. This situation was enhanced by the fact that the plastic was somewhat flexible. When the wheel was mounted on the shaft and all the switches were bearing against one side, the wheel tended to cock itself on the shaft. This aggravated the shimming problem making it even more difficult to adjust the wheel so that all switches would make and break.

Somewhat related was the sixth problem, having to do with temperature coefficients. The temperature coefficient of the Delrin wheel was so much greater than that of the stainless steel shaft that, with a proper operating fit, at room temperature, the wheel would seize on the shaft during cooler temperatures. If the wheel bore was large enough to avoid seizing when cold, it would become too loose at higher temperatures. This would allow the wheel to tilt excessively under pressure of the switches and cause trouble at room temperature and higher.

The last of the wheel problems was again related to effective cam length. Late in the program testing of the indicators under high temperatures and high line voltage showed some indicating wheels tending to spin around and make extra revolutions when running to a number. Extensive investigation traced this problem to the switch. The switch lobe would not follow the actual cam surface as the wheel rotated. That is, the interrupter and #1 data switch, at the greatest distance from the center of the wheel, would lag behind the cam surface as the wheel spun around, which had the effect of extending the cam surface beyond its true length. Figure 12 helps to explain this phenomenon. The action taken to counter this condition consisted of cutting back on the cam for the #1 data switch at the five places where the cam should retract or where the switch should fall back onto the cam. This has proved to be an entirely satisfactory correction for the extended-cam effect which occurred under conditions of high heat and high voltage.

The solution to the other wheel problems, can be quickly reviewed as : a) Correction for the incorrect indexing of the cam due to pawl redesign was accomplished by rotating the base of the wheel mold in relation to the opposite section of the mold, and making all wheels from the mold thus modified. b) No correction was made for the out-of-round condition of the wheels, which results from side-gating of the mold, since the only real solution is to make new wheels from a redesigned mold or a mold reworked for center gating. However, other parts of the pawl have been modified to compensate for this slight imperfection and thereby satisfactory performance has been achieved. c) The matters of uneven cam surface and incompatible thermal coefficients were



ILLUS. NO.
P-0786
PUB 125

FIGURE 12....CAM MODIFICATION

dealt with together by instituting an actual cold temperature fix. The bores of all wheels were drilled out and a moly-bronze bushing inserted. The bushing was then opened up to the size of the shaft plus a minimum clearance of .0004 in. At this time the cam surfaces of all wheels were faced off to be perpendicular within .001 to the bore. These steps effectively overcame the problems of cam unevenness and the difference in wheel and shaft temperature coefficients.

Machining or facing off the cam surfaces, however, posed certain questions. There was the fear that this might remove the hard glazed surface and expose a softer surface of plastic which might pick up some of the grinding compounds. In such case the grinding compounds would wear away the switch lobes. Also, the smoothness of the hard glaze minimized surface friction. However, since the nature of the problem required that the wheels be faced off, a fixture was made to hold the wheels and the machining was done with a very sharp cutting tool. The results were excellent. When the refinished wheels were tested under conditions identical to those before the wheels were machined no further wear was noted nor was any other problem detected. In addition, the wheels that have been machined and bushed allowed the indicator switches to remain in adjustment for a longer period of time.

4.4.2.2

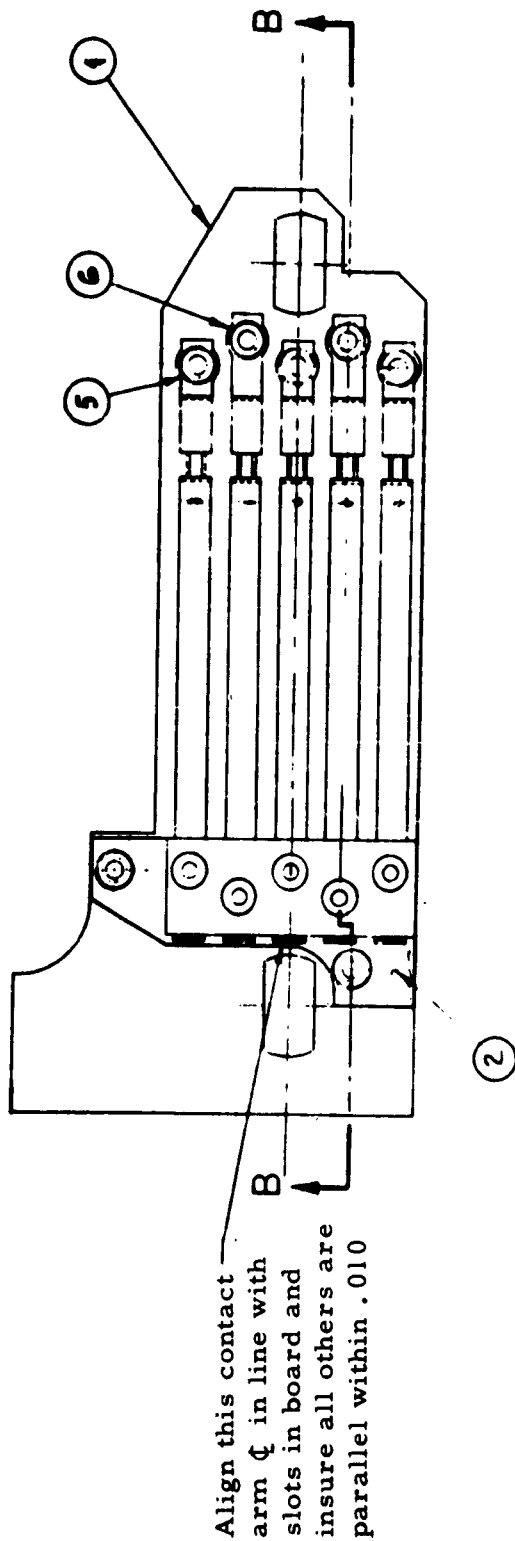
Indicator Switches

The indicator switches referred to here are the set of five required to operate the indicator. The set consists of four single-pull, double-throw switches and one of the single-pull, single-throw type. They are shown in Figure 13. These switches supply the feedback information as to the position, and also time the ON-OFF operations of the solenoid. The original switch design called

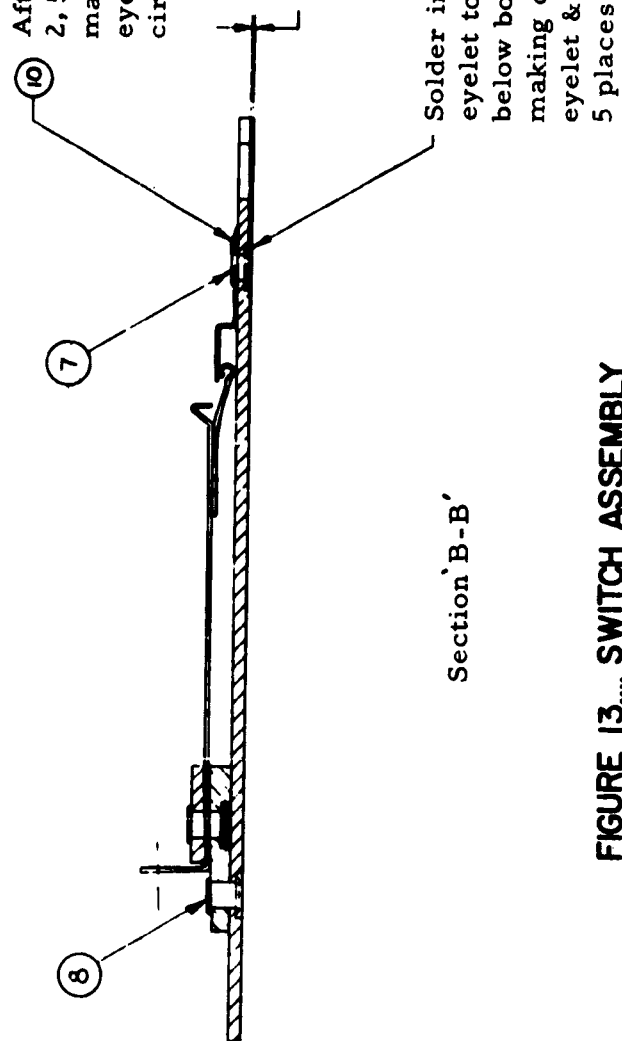
for beryllium copper switch blades, heat treated, nickel plated and overplated with rhodium to provide a hard contact surface. The vendor chosen to produce the original switches had so much difficulty maintaining adequate quality control that SM/I felt compelled to take over fabrication of the switches.

The next difficulty was with respect to the plating material. When the first production indicators were put in service it became evident that they were too readily susceptible to contact fouling. After very short intervals the switch would have to be disassembled for cleaning. Further investigation indicated that the difficulty was due to poor plating contact. The nickel plating was too thick for the purpose and made a rough surface for the rhodium. In turn, the rhodium plating was too thin and did not amply cover the nickel, allowing the nickel to bleed through. This permitted conditions for the formation of nickel oxides on the contacts resulting in fouling. The logical conclusion was to get a better plating job on the switch to prevent the conditions described, or further, to use a switch material of a type that would not foul or need plating. After a careful materials study it was decided to make the entire switch out of paliney.

Paliney is a material compounded of paladium, platinum, gold, silver and copper. It is relatively inert, does not form undesirable oxides and has no "memory" characteristics, which is to say that it does not tend to return to a previous form after being formed to the desired shape -- in this case, the switch. Paliney is a product of the J. M. Ney Company and it was the opinion of their consultant that the SM/I switch design was satisfactory, well adapted to use of the proposed material and that



After alignment of items 2, 5, & 6, apply item 10 making contact between eyelet, contact, & etched circuit 5 places



Section 'B-B'

FIGURE 13.... SWITCH ASSEMBLY

paliney would completely obviate the problems of contact fouling. Switches then were produced having both the top and bottom contacts as well as the arms all made of paliney, with no plating necessary. The parts were made partially by SM/I and partially by J. C. Engineering Company of Santa Monica, a local agent for the J. M. Ney Company. The conversion was well justified by the results which were far superior to the beryllium copper switches plated with nickel and rhodium.

The difficulties were not yet at an end, however, since some of the new paliney switches also began to develop intermittent operation after a time. Investigation uncovered the fact that these switches, after being stamped out and were tumbled in an abrasive compound to remove the burrs. The grinding compound used in the tumbling process contained aluminum oxide and it was theorized that it was this oxide which caused the contact fouling later. The switches were therefore discarded and new ones made. These were stoned by hand to remove the burrs, avoiding any possibility for harmful contamination. The new switches proved to be much better than the first paliney switches but, nevertheless, did develop an objectionable amount of intermittent operation, requiring further corrective effort.

Finally the switch design was modified slightly to the version now in actual use. In this final configuration, the switch assembly is quite similar to the original design, although the actual contact is not made by the surfaces touching as they did before. Instead, contact is really a wiping action. The contact itself is a wire with a round loop on the end and each contact consists of two of these loops, giving it the bifurcated action. The contacts now have more wiping action than before, in view of the

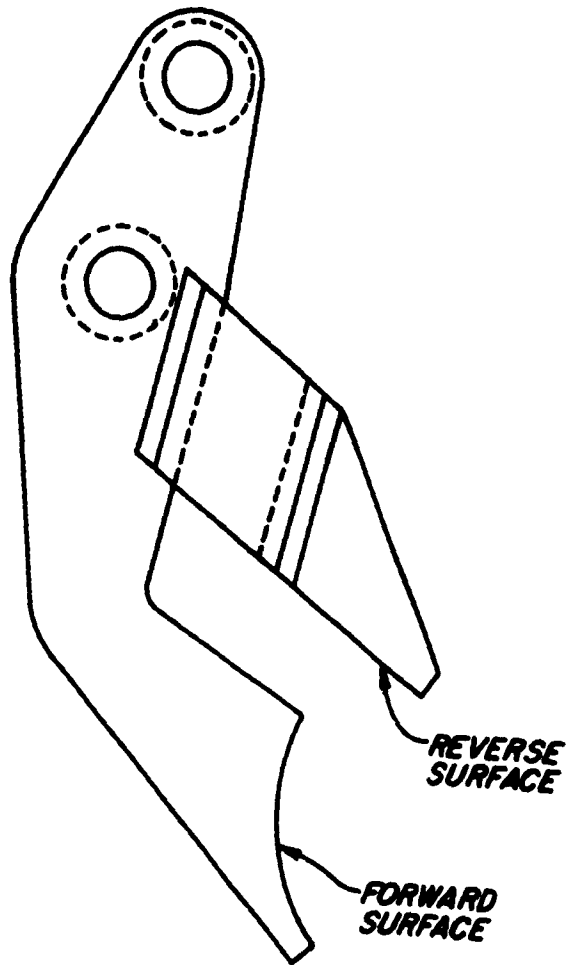
required over-travel. The wipers are of paliney, the top contact is also of paliney and the bottom contact is of gold. This construction provides ample wiper sweep on both the top and bottom and makes a sound contact. After extensive testing these contacts have been found to be far more reliable than any others tried.

4.4.2.3 The Pawl

The subject of pawl design and re-design was treated in Quarterly Report No. 4. It was stated therein that notable progress had been made in this aspect of the project during the fourth quarter. Paragraph 4.4.2.3.1, which follows, reiterates the information given for that reporting period and Paragraph 4.4.2.3.2 covers later developments.

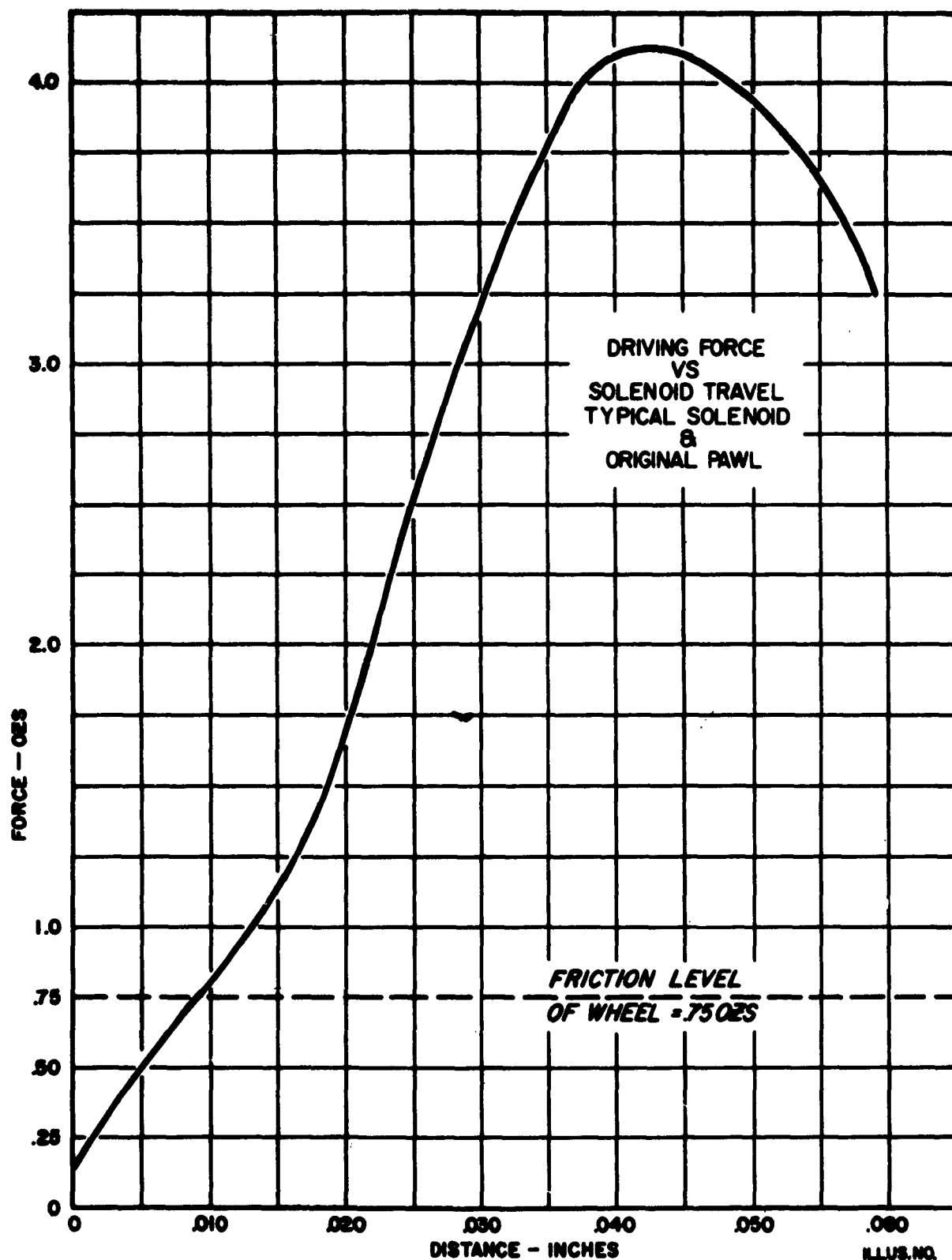
4.4.2.3.1 Developments to 9-30-61

The original pawl had a curved surface which was used to push the wheel along on the forward stroke. (See Figure 14) After extensive testing, it was found that frequently the indicator would hang up or become stalled on the forward stroke near the end of its travel. A reworked pawl, which had the curve filed off was tested, and although this trial pawl had a rough edge and was a crude device, it gave superior results on tests when compared with the smooth standard pawl, as originally designed. A detailed analysis of the pawl was made, checking out the complete mechanics of the pawl wheel. (See Figure 15) As can be seen, when the pawl approaches the limit of its forward travel, the tangential force is less than the frictional force inherent to the wheel. When such a condition



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FIGURE 14..ORIGINAL PAWL



ILLUS. NO.
P-0746

FIGURE 15.. FORCE VS TRAVEL

developed, the mechanism would tend to stick if there was any disturbance. The only reason the indicators had worked for so long was the inertia effect of the pawl pushing the wheel, and the wheel coasted past any point where the friction was greater than the driving force. When the pawl was revised to have a straight edge on the driving surface, the tangential force applied to the wheel was less than before on the initial portion of the stroke but greater than before on the final portion of the forward stroke. The net result was to keep the applied force considerably above the frictional force at all points of the forward stroke. Figure 16 is a comparison of both force ratios for the pawl. Figure 17 is a comparison of the solenoid force required to insure overcoming the frictional force on the wheels for each pawl. As can be seen using the old standard pawl, the solenoid force would have to increase greatly to insure overcoming friction for all points on the forward travel.

At the same time the forward stroke of the pawl was being re-evaluated, the reverse edge was also re-evaluated. The reverse edge is that edge which drives the wheel on to the next number while the solenoid plunger is returning to its relaxed position. On the original pawl, the forward edge was curved and the reverse edge was straight. On the modified version, the forward edge is straight and the reverse edge has

to be slightly curved. The reverse edge was modified slightly at the end to get more tangential force on the reverse operation at the end of the stroke. This enables the spring and pawl combination to give the wheel the last little kick required to make the interrupter when coming into a new number.

An indicator with the modified pawl was set up with the test equipment and operated for approximately 38 hours at the rate of one revolution every two seconds. This indicator made an estimated 68,000 revolutions during the test period. This compares favorably with the estimated life under the Philco contract of 60,000 revolutions. Figure 18 depicts the modified pawl.

4.4.2.3.2 Developments Since 9-30-61

The latest improvement of the pawl was the addition of "Molykote" to all working surfaces on the pawl.

"Molykote" is the trade name of a molybdenum disulfide lubricant and its use reduced friction and wear at all temperatures.

4.4.2.4 Solenoid, Solenoid Mounting and Plunger Mounting

During the extensive testing to which the indicator was subjected, certain modifications were necessary for the solenoid and its mounting arrangement. The mounting bracket was found to slip during operation and a locking plate had to be provided. This was a minor matter but the plunger problem was not so simply resolved. Originally the solenoid plunger

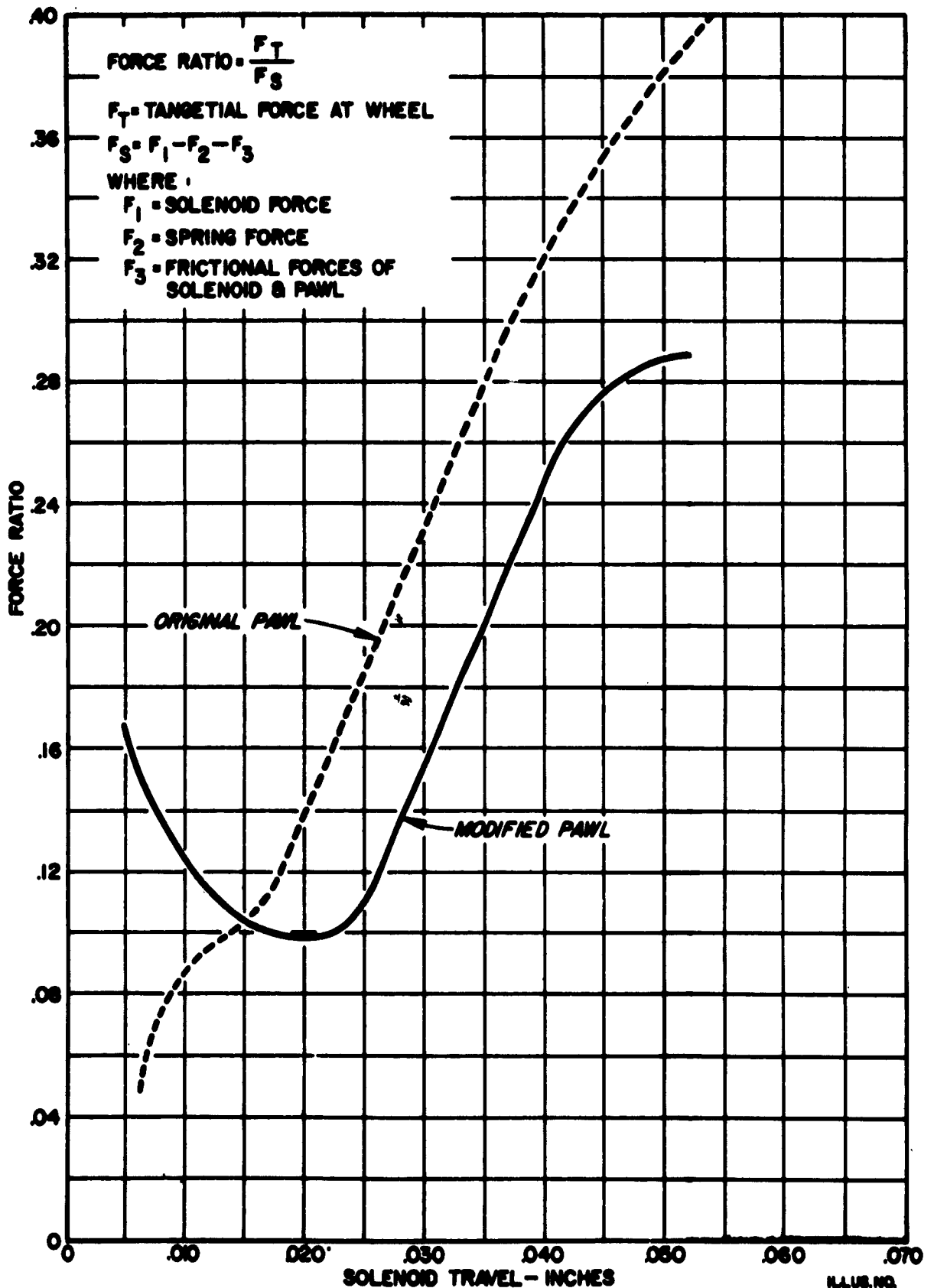
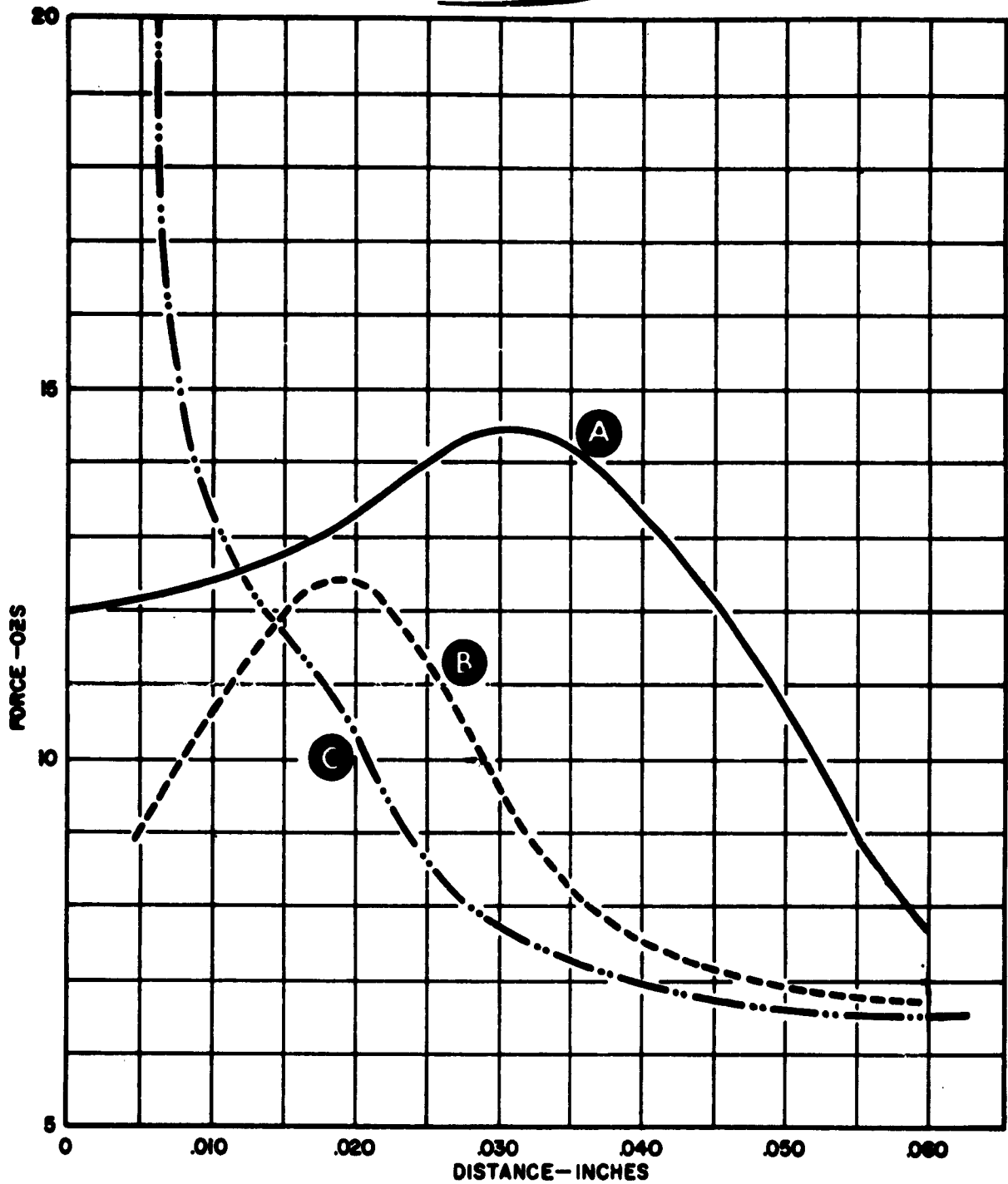


FIGURE 16 . FORCE RATIO

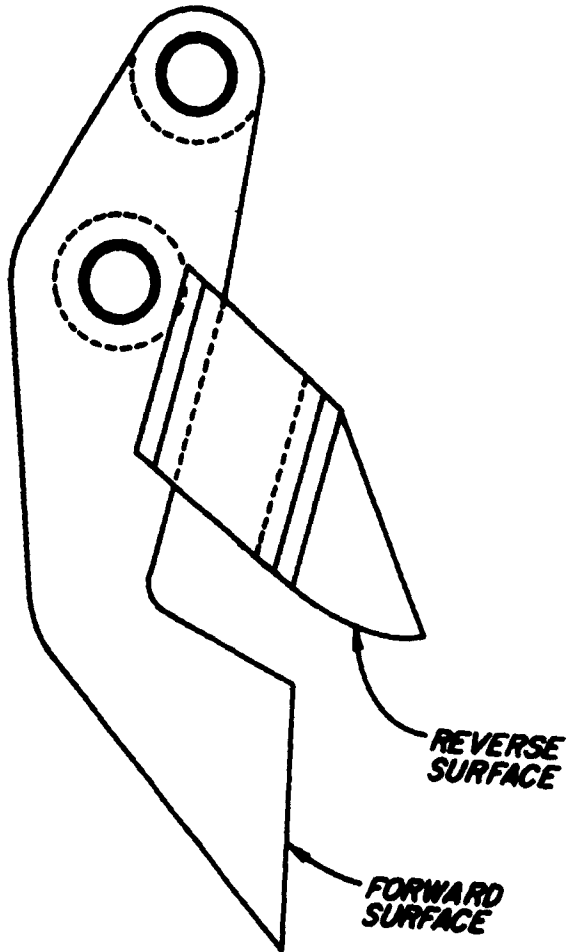


- A** TYPICAL SOLENOID CURVE
- B** REQ'D SOLENOID CURVE FOR MODIFIED PAWL
- C** REQ'D SOLENOID CURVE FOR STANDARD PAWL

ILLUS NO
P-0748

FIGURE 17. SOLENOID FORCE

SM/I



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P-0749

FIGURE 18 ..MODIFIED PAWL

was free to move on the linkage arm. Subsequently several attempts to anchor it to the linkage arm in a more solid fashion were made but all of these were eventually discarded. It was determined that the free movement was best and, as refined in the final unit, no problem from this source has been noted.

The mounting of the solenoid itself has undergone a slight change that is worthy of mention. At first the solenoid was mounted solidly on its bracket, a right-angle support directly behind the solenoid. However, during the intensive testing it was observed that the solenoid and indicators operated more smoothly when the solenoid was free to roll slightly. For this reason a bracket was produced which provides a floating solenoid and this bracket is now in use.

Power from the solenoid has consistently gone up, which makes for a highly reliable indicator. The original indicator operated from 85 V \pm 15 V whereas the present indicator operates from 120 V \pm 20 V. The resistance of the solenoid is 450 Ω nominal. This calculates to a value of 16 watts under the original voltage input and 32 watts under the present one. This power is dissipated only while the indicator is running. The excess power is used to insure that the force from the solenoid exerted on the wheel is much greater than the amount required to overcome friction or any other resistance and insure that the unit will operate over the wide temperature of -25° F to +132° F.

Another slight change in the indicator concerned the return spring which exerts force on the pawl to return the wheel to the "home" position when power is removed. The modification amounted merely to providing an improved means of anchoring the ends of the spring to the arm.

4.5 Fabrication and Delivery

The first Forward Area Display Unit was scheduled for delivery in July of 1961. Due to the problems described earlier herein, the first unit did not become available for complete system testing until late September of 1961. During the system testing procedure it became evident that there was still some problem in the indicators relative to cold temperature operation. Indicator functioning was found to be unsatisfactory at temperatures much below $+20^{\circ}$ F. At this point a corrective program was begun with the particular objective of perfecting the bushing and refacing of the wheels as detailed in Paragraph 4.4.2.1. All indicators were dismantled, reworked, reassembled and again subjected to thorough testing. It was during this interval that the switches also were modified to the final version, as discussed in Paragraph 4.4.2.2. This program, centered on the indicator wheels and switches, extended through October and November, 1961, and the complete unit again became available for system testing in mid-December.

The December testing of the Forward Area Display Unit disclosed the presence of a few remaining undesirable operating characteristics:

- a) Under high voltage, high temperature conditions it was noted that some indicators would make extra revolutions occasionally before stopping at their commanded numbers. (See Paragraph 4.5.1 below.)
- b) Under cold temperature conditions, when repetitively transmitting the same data, the indicators showed some tendency to creep gradually further around on each stop until the number was hidden, or partially so, beyond the frame of the window. Then, when it crept to a point beyond the range of the stop position completely, it would drive on around for another complete revolution before bringing the correct number into position. (See Paragraph 4.5.2 below.)
- c) Certain other minor faults such as the insecure switch handle and loose window were observed and these were easily corrected.

4.5.1 High Temperature, High Voltage Spinning

This problem was put under concerted study and a satisfactory solution was reached. It had been noted that the high temperature, high-voltage spinning occurred when the indicator was driving toward an even number (0, 2, 4, 6 or 8) which requires that the #1 data switch must fall off its cam. At such times, when

running at high speeds, the #1 data switch showed a tendency not to follow the cam closely enough which gave the effect of an extended cam length. Therefore, at the instant when the wheel slipped home, a spike would often occur just at the time the switch should "make", causing the wheel to drive on past the window. The wheel would then continue around until the intended number came up again and, if no spike occurred this time, it would stop. This was dealt with by cutting back on the #1 data cam as explained in Paragraph 4.4.2.1. This alteration was performed on sample indicators which were then extensively tested. Upon being satisfied that this alteration had successfully overcome the difficulty, all of the indicators were modified in this manner for both S/N 1 and S/N 2.

4.5.2. Cold Temperature Creeping

This difficulty was surmounted by a circuit alteration in the sequencing unit and test unit. The sequencing operation dictated that any indicator which was to receive data would first be reset and then the data would be supplied. Thus the reset pulse would reset the flip-flops and would be followed by the data pulses which would set specific flip-flops. For example, if an indicator stands at 5 and then again is to receive a 5, it will first be reset to zero before proceeding to 5.

As it is designed to operate, the indicator momentarily receives an error signal telling it to drive and immediately thereafter receives the correct signal telling it to hold. For the brief duration of that error signal the pawl will start to move forward and hit the wheel lightly, then move back again. When the pawl slips back the wheel also slips back into position.

However, under cold temperature conditions, with friction consequently greater than normal, the wheel would slip forward under the light impact of the pawl and would stay at that point, in some cases, after the pawl had retracted. If the same number was transmitted again, the wheel would be advanced another fraction of an inch. Little by little in this manner the wheel would advance until the location of the number was beyond the viewing window. This chain of events would happen under the normal mode if the same data were transmitted several times in succession or at frequent intervals. It would also happen under a test mode, in which the data is always transmitted repetitively.

4.6 Temperature Testing

4.7 Summary

800-441-2344/1000.

Section 5**CONCLUSIONS AND RECOMMENDATIONS****5.1 Conclusions**

The ultimate result of the program to develop a Forward Area Display Unit is that a portable system for use in the field, as envisioned by the Signal Corps and defined by the Philco specification, has been proved feasible and fully tested operating units have been produced. The final equipment as developed by Servomechanisms/Inc. meets all of the requirements of the covering specification. Total size and weight are such that the unit can be handled under anticipated conditions by one individual. Components are packaged in modular fashion to facilitate maintenance. SM/I considers that the unit delivered to Philco will be found satisfactory by all parties concerned.

5.2 Recommendations

There are only two recommendations which Servomechanisms/Inc. would like to offer.

5.2.1 Frequency of Input Signals

If the input frequency were to be reduced from 9-3/8 cps to 3 cps the following advantages could be gained:

- a) The separate memory circuit for each indicator would be unnecessary, since the indicator can position itself to the correct number within the 1/3-second allowable. This would result in cost savings all the way through the program, not to mention the factors of weight and maintenance.
- b) The power supply could have better regulation, thereby passing on a saving to the indicator. This is feasible since only one indicator can be running at a time.

5.2.2 Circuit Board Attachment

SM/I is prepared to suggest improved means of attaching the small circuit board to the large plug-in boards, with the result of facilitating maintenance.



PUBLICATION 125-A
ADDENDUM TO
PUBLICATION 125

FORWARD AREA DISPLAY UNIT

REPORT NO. 5
CONTRACT: DA36-039-SC85146

FINAL REPORT
per PHILCO Specification
9S 3333B and Revision 'C'
Dated 4/10/61

*This Addendum
Dated September 1, 1962
is a Part of
The Fifth and Final Report
of the FADU Series Prepared for
PHILCO CORPORATION
by
SERVOMECHANISMS/INC.
which Covers the Period
from
1 October 1961
to
9 March 1962*

**Publication 125-A, Addendum to Publication 125 Final Report to Philco Corp.
on Forward Area Display Unit, SM/1 Type CTI 602**

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ADDENDUM TO THE FINAL REPORT TO PHILCO ON FORWARD AREA DISPLAY UNIT, SM/I TYPE CTI 602

Section 1

STUDY OF FADU S/N 1 RETURNED FOR REPAIR

In March of 1962 FADU S/N 1 was returned to Servomechanisms/Inc. for repair. A study was conducted of the causes for malfunction and the corrective measures required.

1.1 Malfunction Investigation

The most obvious malfunctions were, first, that one of the indicators did not operate at all and, second, that several other indicators operated erratically.

Upon examination it was found that several of the 1% resistors (Dale Products, Inc., Type DCF 1/10 and DCF 1/4) were broken. Also, during temperature testing of the unit, the indicator power supply failed.

1.2 Indicator Operation

It was noted that the one indicator which did not operate had an open solenoid. This caused a small positive DC voltage to be superimposed on the spikes from the indicator power supply. Because of this positive voltage the Silicon Controlled Rectifiers in other indicators were not always allowed to turn off. Hence the affected indicators would operate erratically. When the faulty solenoid was replaced the indicators functioned in a normal manner.

1.3 Resistor Breakage

At first it was theorized that the broken resistors were caused by a difference between the temperature coefficient of expansion of the resistors and that of the moisture proofing compound used to coat the boards. To test this theory, a sample board was made up and coated with the same moisture proofing compound used in the FADU. The sample board was repeatedly cycled between -50°F and +180°F. No resistors broke during these tests. Other possible causes are conceivable, of course, but the most likely assumption now appears to be that the resistors were broken by rough handling.

1.4 Indicator Power Supply

In the power supply, it was found that SCR 101 was open. This was caused by excessive voltage across it. The excessive voltage resulted from the breaking of a wire which was connected to CR 117, a Zener diode used to limit voltages across this SCR to a safe value. How the wire parted is conjectural.

1.5 Test Mode Modification

In order to protect the indicators in the FADU from undue wear, the test circuit was modified so that during the test mode the indicators would operate only while the test button was held manually in the test position. The modification consisted of routing through the test button the $\frac{1}{2}$ 12V necessary to operate the test sequencer instead of taking it directly from the $\frac{1}{2}$ 12V power supply. This alteration was incorporated in both the S/N 1 and the S/N 2.

Section 2

RECOMMENDATIONS FOR IMPROVING THE FADU OPERATION

On the basis of the findings described in the foregoing paragraphs, as well as other observations since Report No. 5 was submitted, it is felt that certain specific improvements should be considered.

2.1 Suggested Improvements of the ID 2005 Indicator

There are four principal areas for improvement in the ID 2005 Indicator:

1. The solenoid and the solenoid mounting.
2. The switch.
3. The sealing of the indicator.
4. The logic assembly.

2.1.1 The Solenoid and Solenoid Mounting

The solenoid itself could be improved by making it slightly longer and having a better surface finish in the bore and on the armature of the solenoid. Another opportunity for improvement in this area is the manner in which the solenoid is mounted. It is suggested that this mounting be of such a nature as to enable the case of the indicator to act as a heat sink for the solenoid. In addition, it is advisable to use another method of attaching the armature to the solenoid arm. The new arrangement should give the armature maximum freedom of motion. It is necessary to provide this freedom of motion in order to prevent the armature from being forced against the bore of the solenoid during its operation.

These proposed improvements would provide a greater safety factor for the unit by delivering more force from the solenoid and by making more efficient use of that force, with the additional benefit of dissipating the heat generated by the solenoid.

2.1.2 The Switch

There is need to improve the switch both for better performance and to simplify manufacture. The present switch design does not

lend itself to assembly tooling and requires that a considerable amount of the assembling be done by hand. With regard to performance, the switch has a tendency to bounce, which can cause spinning at high temperatures and high line voltage.

2.1.3 The Indicator Sealing

Although the CTI 602 is sealed as a unit, the indicators need to have at least a dust seal to keep the indicators' parts (solenoid, switch, code wheel) free of foreign matter while the CTI 602 is open for servicing and maintenance in the field. It is acknowledged that this would require a change in the design of the indicator itself but could include making the indicator easier to assemble and service.

2.1.4 The Logic Assembly

It is recommended that the logic assembly be modified to make it easier to remove and replace the individual welded modules. This would entail adding a connector between the switch and the logic assembly.

2.2 Suggested Changes to the FADU Circuitry

It is now apparent that there are three areas in which circuit modifications would result in operating advantages:

1. The Test Circuit.
2. 24-Volt Operation.
3. High-Speed Operation.

2.2.1 The Test Circuit

It is readily possible to modify the test circuit so as to test out a greater portion of the FADU system circuitry, and the change would result in a simpler test circuit. During test mode a uni-junction transistor would generate an internal strobe signal equivalent to C1' in the present unit. Also, during test mode, DC voltages equivalent to binary one and binary zero inputs would be applied to the circuits of the input buffers. Thus a

greater portion of the FADU could be tested, and in a way that more closely simulates the operation of the FADU in normal mode.

2.2.2 Operation at 24 Volts

Since the FADU may be required to operate in regions where 115VAC is not available, the unit could be adapted for operation from 24VDC. This could be accomplished by changing the present AC-to-DC supply to a DC-to-DC converter.

2.2.3 High-Speed Operation

If it becomes necessary to operate the FADU at speeds higher than the 9.375 cps now used, information could be fed into the indicator memory flip-flops and the last transmitted character (i. e., the EOM signal) would also serve as a readout command, at which time the indicators would sequentially readout the information stored in their memories. Data transmission rates up to 100,000 bits per second with 2.5 seconds readout time for indicator operation are possible.

This mode of operation has the advantage of reducing transmission link time by a factor of 75/100,000 over the present unit. As an example, for a 27 character message, (FADU address, character, 25 data characters and end of message character) the present unit will require 2.53 seconds of transmission time. The corresponding transmission time for the high-speed version would be 2.16 milliseconds, a decided improvement. In either case, it takes 2.5 seconds to complete the transfer of information from the FADU memory register to the electromechanical indicators.

ADDENDUM TO
SUBSYSTEM SSIA FINAL ENGINEERING REPORT

Covering the Period
1 January 1963 to 1 May 1963

Contract DA-36-039-SC-85146

Department of the Army File No. 39586-PM-60-91-91 (6441)

PHILCO

A subsidiary of *Ford Motor Company*

COMPUTER DIVISION
WILLOW GROVE, PA.

ADDENDUM TO
SS1A Final Engineering Report
(Covering the Period 1 January 1963 to 1 May 1963)

SECOND I/O CONVERTER FOR BASICPAC SERIAL NO. 7 AND
ASSOCIATED PROGRAMS

A. HISTORY

In the latter part of June 1962, contract modification No. 7 to Signal Corps Contract DA-36-039-SC-85146 for the SS1A subsystem was issued. Modification No. 7 authorized the task of providing the necessary hardware and documentation, including programming, to incorporate a second Input/Output Converter in BASICPAC Serial No. 7.

The second Input/Output Converter was assembled, tested and debugged, in part, with serial No. 3 system at Philco in preparation for shipment to Fort Huachuca, Arizona, in January 1963.

The programs designed to test a multiple input/output converter computer include PACO (Paper Tape Test - Input/Output Converter) and SICON (Simultaneous Converter Operations Test). These programs had been partially finished at the writing of the final report; however, assembly, debugging and final documentation required use of serial No. 7 with an operating second Input/Output Converter for completion.

The BASICPAC Programmers Manual and FAP II (Fielddata Assembly Program II), nearly complete, were scheduled for final delivery in early 1963.

To prevent undue delay in the delivery of the Final Engineering Report for the SS1A, the then existing status of the above items was included in the report together with mention of a following addendum. This addendum would cover the remainder of the work required to complete the task.

B. INTEGRATION

After thorough testing of the second Input/Output Converter at Philco by the Signal Corps, the unit was packed in a transit case and shipped from Philco on 17 January 1963. Upon arrival at Fort Huachuca, the unit was installed in the allotted cabinet in BASICPAC Serial No. 7. Installation and minor card modification was completed by January 31, 1963. Wiring changes on the first input/output converter were completed the following day.

Final test and debugging operations began February 5 and were completed by February 10, 1963. In this interval all the converter operations were checked and, after minor debugging, were found to operate correctly. The only problems found were, a) the paper tape reader and punch cables were reversed in unit cabinet J-16, b) six wires were pinched under the cover plate of cable penthouse cover of unit J-33. The latter problem caused minor damage to components on one card in the Input/Output converter. After repair of the above items, tests were completed and the input/output unit was found to operate according to specification.

Therefore, it can be concluded, that the integration of the Second I/O Converter for BASICPAC Serial No. 7 into the frame previously cabled for it, was highly successful.

C. PROGRAMMING

This portion of this addendum describes the work done from December 31, 1962 until May 1, 1963, to complete the programming tasks required by contract number DA-36-039-SC-85146. The work was divided into four areas; 1) completion and delivery of the BASICPAC Programmers Reference Manual, 2) completion of PACO (paper tape set and I/O converter test program, 3) completion of SICON (simultaneous use of two I/O converters) and, 4) completion of FAP II (FIELDATA Assembly Program).

1. BASICPAC Programmers Reference Manual

This document was completed and delivered to USAERDL in February 1963.

2. Revision of the Input/Output Converter diagnostic, PACO, to accommodate testing of a two Input/Output Converter System

PACO (Paper Tape Test - Input/Output Converter) is designed to test both the operation of an Input/Output Converter and the mechanical and electrical functioning of the Kleinschmidt Typewriter, Paper Tape Punch, and Paper Tape Reader. Flow charting, coding, program description and operating instructions for the program were completed prior to December 31, 1963. Program assembly was completed at Fort Monmouth in February, 1963. Program debugging was initiated at Fort Huachuca on BASICPAC No. 7 on February 28, 1963, and continued until March 22, 1963. Problems with the paper tape sets and machine scheduling prevented the completion of debugging at the Fort Huachuca installation. Final debugging, assembly, listing for documentation, and tape duplication was accomplished during April at Fort Monmouth utilizing BASICPAC No. 1 and the off-line synchrotypers.

Program tapes and Book 7 of the BASICPAC Program Library including PACO program descriptions, operating instructions, flow charts, and program listings were completed and delivered in May 1963.

3. Preparation of a Diagnostic Program, SICON, for the Testing of Two Input/Output Converters Operating Simultaneously

SICON (Simultaneous Converter Operations Test) is designed to examine the multiplexing functions performed during simultaneous operation of two Input/Output Converters. Flow charting, coding, program description, and operating instructions for SICON were completed in April, 1962. Program assembly was completed at Fort Monmouth utilizing BASICPAC No. 1 in February, 1963. Program debugging was undertaken on BASICPAC No. 7 at Fort Huachuca on February 28, 1963. Problems with the paper tape sets and machine scheduling hampered the progress of the debugging phase. Because the second I/O Converter had recently been installed, and therefore was not thoroughly debugged, a minor problem in its operation was encountered but quickly repaired by Philco personnel. Despite these difficulties SICON was successfully debugged prior to March 22, 1963. Final program assembly, listing for documentation, and tape duplication was accomplished at Fort Monmouth on BASICPAC No. 1 during April.

Program tapes for SICON and Book 7 of the BASICPAC Program Library including program descriptions, operating instructions, flow charts, and program listings were completed and delivered in May, 1963.

4. Re-design of FAP II for Capability of Handling Subject Programs Designed for Two-Memory, Two Input/Output Converter Systems

Flow charting and coding of the re-designed FAP II was completed prior to December 31, 1962. Final debugging, documentation, assembly listing, and tape reproduction was completed on BASICPAC No. 1 and the off-line synchrotypers at Fort Monmouth. Program tape and Book 13 of the BASICPAC Program Library containing the FAP II listing, flow charts, and a brief technical description were completed and delivered in May 1963.

DISTRIBUTION LIST

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TASK NO. 3B28-04-001-01-15

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TITLE: Equipment for USAEPG Artillery Sub-system

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